

Design of Automotive Sun Visor System

A Dissertation Submitted
In Partial Fulfilment of the Requirements
for the Degree of

Master of Engineering
in
CAD/CAM Engineering

by

Sourabh Dewedi
Roll No: 801381022

Under the guidance of

Mr. Ravinder Kumar Duvedi
Assistant Professor
Mechanical Engineering Department
Thapar University, Patiala-147004

Dr. Sandeep Kumar Sharma
Assistant Professor
Mechanical Engineering Department
Thapar University, Patiala-147004



to the

MECHANICAL ENGINEERING DEPARTMENT
THAPAR UNIVERSITY, PATIALA

July, 2015

CERTIFICATE

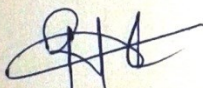
I hereby certify that the work which is being presented in this thesis entitled “ **Design of Automotive Sun Visor System**” being submitted by **Sourabh Dewedi**, in partial fulfilment of the award of **Master’s Degree in CAD/CAM Engineering** Submitted in Mechanical Engineering Department of Thapar University, Patiala is an authentic record of my work carried out under the supervision of, **Mr. Ravinder Kumar Duvedi, Assistant Professor, Mechanical Engineering Department and Dr. Sandeep Kumar Sharma, Assistant Professor, Mechanical Engineering Department, Thapar University, Patiala.**


The study embodied in this thesis has not been submitted in part or full to any other university or institute for the award of any degree.

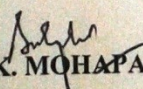
Dated: 14/07/2015


(Sourabh Dewedi)

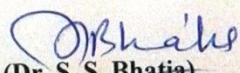
It is certified that the above statement made by the student is correct to best of my knowledge and belief.


(**Mr. Ravinder Kumar Duvedi**)
Assistant Professor
Mechanical Engineering Department
Thapar University, Patiala-147004


(**Dr. Sandeep Kumar Sharma**)
Assistant Professor
Mechanical Engineering Department
Thapar University, Patiala-147004


(**Dr. S. K. MOHAPATRA**)
Professor and Head
Mechanical Engineering Department
Thapar University, Patiala-147004

Countersigned By:


(**Dr. S. S. Bhatia**)
Dean of Academic Affairs
Thapar University, Patiala-147004

Dedicated to
My Parents

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to **Mr. Ravinder Kumar Duvedi, Assistant Professor** and **Dr. Sandeep Kumar Sharma, Assistant Professor Mechanical Engineering Department, Thapar University, Patiala** for their sincere & priceless guidance, suggestions. Their valuable ideas helped me a lot in my work. They helped me to organize this vast topic in concise way. Their flawless and forth right suggestions blended with an intelligent application have crowned my task with success.

I would like to thank entire faculty and staff of **Mechanical Engineering Department, Thapar University**, for their help and support in successful completion of my thesis work.

I would also like to thank Mr. Sumit Sood for his valuable help.

Sourabh Dewedi
Roll No.- 801381022

ABSTRACT

In this study a semi-automatic passenger car sun visor has been designed. The aim for development of the new sun visor design is to protect passenger car driver from sun glare while driving considering the sun glare effect in various positions of sun. Conventional sun visor systems used in passenger cars are effective only when sun is high in the sky and these visor systems are required to be positioned manually. Various studies related to vehicle accidents have shown that the sun glare is most dangerous when sun is near to the horizon at the time of sun rise and sun set. Many studies have been done in the developments in the area of sun visor screens or also called sun visor extensions. In this study length and width of the visor has been ergonomically calculated for the car model chosen based on the anthropometric data for Indian population. Data for car interior dimensions has been borrowed from Porsche engineering services [29]. Indian anthropometric data has been borrowed from Indian institute of technology Guwahati's website [28]. Modelling has been done according to the vehicle interior design terminologies and standards given by SAE and ARAI. The designing of the sun visor system is carried out in 3D CAD environment of Pro-E 5.0 (education version). The material selection for various components developed for the sun visor system has been done as per available ARAI standards. The analysis for testing the mechanical properties like stresses and deflections for the key components has been carried out in Pro-Mechanica and Ansys 14.0. The results for various iterations and the final designed components have been discussed in details in this thesis work. The analysis results for the final design of various components of the sun visor system are quite satisfactory and hence the designed model can be used as reference for creation of similar sun visor systems for other commercial and non-commercial vehicles.

TABLE OF CONTENTS

CERTIFICATE	ii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
LIST OF FIGURES	viii
LIST OF TABLES	x
NOMENCLATURE	xi
CHAPTER 1: INTRODUCTION	1
1.1 Types of Sun Glare	2
1.2 Effects of Sun Glare	2
1.3 Solar Radiation	2
1.4 Protection from Sun Glare Effects	3
1.5 Passenger Car Sun Visor	3
1.5.1 Flaws in Passenger car visor systems	4
1.5.2 Efforts to overcome flaws of Passenger Car sun visor	4
1.6 Sun Visor Extension for sun glare protection	5
CHAPTER 2: LITERATURE RIVIEW	6
2.1 Cabin Visibility Standards For Automobile	6
2.2 Glare Problem During Driving And Proposed Remedial Solution	7
2.3 Material for Automobile Interior And Visor	9
2.4 Ergonomics Data for Indian Population	10
2.5 Conclusion	10
CHAPTER 3: CONCEPTUAL DESIGN OF VISOR SYSTEM	11
3.1 Design Constraints	11
3.2 Design Parameters	11
3.3 Throw Length of Visor	11
3.3.1 Passenger car cabin design terminologies	12
3.3.2 Passenger car cabin design	14
3.3.3 Determination of location of Eyellipse points	15
3.4 Width of the Sheet	19
CHAPTER 4: DESIGN AND MATERIAL SELECTION FOR VARIOUS	23

COMPONENTS	
4.1 Anti-glare Sheet	26
4.2 Sheet Holder	29
4.2.1 Protrusion design	30
4.3 Design of Wheel for Moving the Visor Sheet Sub Assembly	35
4.4 Design of Rollers for Vertical Support of Visor Sheet Sub Assembly	36
4.5 Motor Selection for Actuation of Visor Sheet Sub Assembly	37
4.5.1 Finding the Belt length	39
4.6 Crash Analysis of Visor Sheet	39
4.7 Main Casing of the Visor System	41
4.8 Analysis of Motor Mounting Support	41
4.8 Design of Visor System Casing Cover	42
CHAPTER 5: CONCLUSION AND FUTURE SCOPE	43
5.1 Conclusion	43
5.2 Future Scope	44
REFERENCES	45

LIST OF FIGURES

Figure 1.1	A typical sun glare scene	1
Figure 1.2	Types of UV rays	3
Figure 1.3	Car sun visor.	4
Figure 1.4	Visor extension.	5
Figure 2.1	Solar position at accident spot.	7
Figure 3.1	Eyellipse position of small, average & tall height driver in profile & top view	12
Figure 3.2	Driver's cabin height dimensions.	12
Figure 3.3	Driver's cabin length dimensions.	13
Figure 3.4	SgRP point location in xyz coordinate system.	14
Figure 3.5	Eye point template location (E_{tl}) in sitting posture	15
Figure 3.6	Buttock to extended leg comfortable length (B_{ecl})	16
Figure 3.7	H-point template for 95 th percentile passenger car driver.	17
Figure 3.8	'P' point location in top and profile view	17
Figure 3.9	Top view of an available car model	18
Figure 3.10	Eye point location of female and male driver in profile view.	18
Figure 3.11(a)	Visor through length calculation for 95 th percentile Male driver	19
Figure 3.11(b)	Visor through length calculation for Female driver	19
Figure 3.12	Driver cabin width dimensions.	20
Figure 3.13	Eye point location of female & male driver in top view.	21
Figure 3.14(a)	Calculated width for female driver	21
Figure 3.14(b)	Calculated width for male driver	22
Figure 4.1	Visor assembly	24
Figure 4.2	Exploded view	25
Figure 4.3	Polycarbonate sheet drawings.	27
Figure 4.4	Applied force direction and fixed support	27
Figure 4.5	Stress and deformation result of 1mm thick sheet.	28
Figure 4.6	Results for sensitivity analysis of Sheet thickness (D0) with respect to displacement and stress values under 10N force	28
Figure 4.7	Anti-glare sheet self-weight deformation results applying gravitational force analysis.	29

Figure 4.8	Sheet holder drawings.	30
Figure 4.9	Drawings of initially designed protrusions	31
Figure 4.10	Direction of applied force	31
Figure 4.11	Stress and displacement result of initially designed protrusion part under 10N applied force.	32
Figure 4.12	Re-designed protrusion part drawings.	32
Figure 4.13	Results for sensitivity analysis of Gap dimension (d21) with respect to displacement and stress values achievable between two faces of wheel holder protrusion under 10N force.	33
Figure 4.14	Results for sensitivity analysis of Angle dimension (d37) with respect to displacement and stress values achievable between two faces of wheel holder protrusion under 10N force.	33
Figure 4.15	Results for sensitivity analysis of Radius dimension (d36) with respect to displacement and stress values achievable between two faces of wheel holder protrusion under 10N force.	33
Figure 4.16	Optimized protrusion part drawings.	34
Figure 4.17	Stress and displacement analysis results for the final protrusion model	34
Figure 4.18	Wheel part drawings	35
Figure 4. 19	Roller drawings.	36
Figure 4.20	Visor inclination angle with horizontal line.	37
Figure 4.21	Motor drawings	37
Figure 4.22	Anti-glare film crash analysis result	40
Figure 4.23	Main casing part drawings.	40
Figure 4.24	Stress and deformation analysis of motor mounting under belt tension(applied force is 2N)	42
Figure 4.25	Assembled visor system	42

LIST OF TABLES

Table 3.1:	Car interior dimensions.	14
Table 3.2:	Eyellipse template location data for Indian population.	15
Table 3.3:	Buttock to extended leg comfortable length for Indian population.	16
Table 4.1:	Mechanical properties of Polypropylene material.	26
Table 4.2:	Mechanical properties of polycarbonate material.	29
Table 4.3:	Mechanical properties of steel material.	36

NOMENCLATURE

Symbol	Description
<i>SgRP</i>	Seating reference point.
<i>SAE</i>	Society of automobile engineers.
<i>ARAI</i>	Automotive Research Association of India.
<i>AIS</i>	Automotive industry Standards.
<i>ASTM</i>	American society for testing and materials.
<i>DLO</i>	Day light opening.
<i>E_{tl}</i>	Eyellipse template location.
<i>B_{ecl}</i>	Buttocks to extended leg comfortable length.
<i>UV</i>	Ultra violate.
<i>Pvc</i>	Poly vinyl chloride.
<i>P_f</i>	Pulling force.
<i>I_f</i>	Inertia force.
<i>R</i>	Normal reaction.
<i>F_f</i>	Friction force.
μ	Coefficient of friction.
<i>m</i>	Mass.
<i>g</i>	Gravity.
<i>N</i>	Newton.
<i>T_{designed}</i>	Designed torque.
<i>T_{motor}</i>	Motor torque.

CHAPTER 1

INTRODUCTION

Clear Visibility is the basic need for safe driving. If driver does not have clear vision it could lead to fatal results. While driving early in the morning or late in the evening at the time of sunrise or sunset it has been observed that sun glare effect is very dangerous for driver and many studies have shown that many accidents occurs when sun is near to the horizon. Figure 1.1 shows view of sun at the time of sun set and it shows that how dangerous it is at the time of sun set.

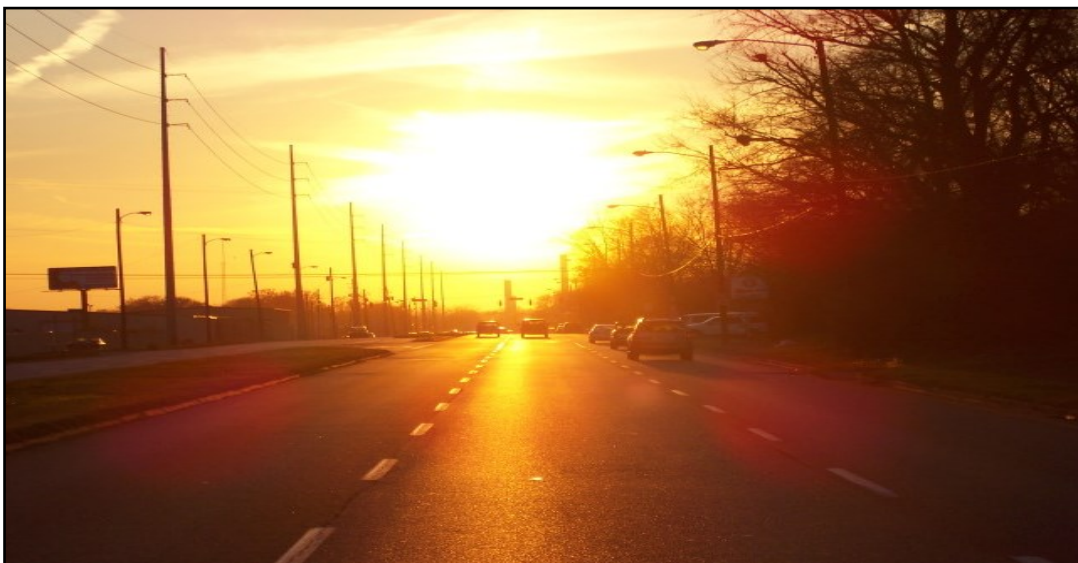


Figure1.1: A typical sun glare scene [32]

In many ways sun light can make driving very difficult. It can affect driving task at a wide range of angles relative to the driver. In addition to direct sun light glare reflections from other vehicles and nearby building glasses may also contribute to glare. In vehicles conventional sun visor is provided to screen out sun glare effect while driving and is attached on upper DLO (Day light opening) of windshield. Conventional visor works perfectly when sun is high in the sky. But when sun is low near to the horizon conventional visor is not very effective, as it could not screen out sun light completely. It is been observed that shorter people face more difficulty than average or taller people because visor is not so effective for small height driver when sun is high in the sky. Mostly shorter people choose to position themselves closer to the windshield to have easy control over clutch, speed and brake pedal. Also for vision driver has to sit closer to windshield. In such cases sun visor which is attached to the upper DLO of the windshield is not so effective for driver.

1.1 Types of Sun Glare

Sun glare does not only cause sudden blindness to driver, but it also causes problems like headache, eye pain skin disease and other skin problems. So the sun glare is primarily divided into two types that is disability glare and discomfort glare.

(i) Disability glare

Disability glare reduces the clarity of vision and reduces contrast. When driver faces this type of situation, driver usually tries to slow down the vehicle because of the vision discomfort. Sudden disability glare some time put drivers into an awful situation.

(ii) Discomfort glare

Discomfort glare is sunlight effect which causes headaches and eye pain. Although it does not interfere with driver's vision but drivers are exposed under sun light for long time, discomfort situations like headache, eye pain and skin disease may occur. Prolonged exposure to sun light some time may cause skin cancer in certain cases.

1.2 Effects of Sun Glare

Sun glare may result into discomfort, blindness, vision obstruction, skin irritation and other skin diseases. Sun glare making it difficult for drivers to recognize traffic signals. Prolonged expose to sunlight can cause sun burns and skin cancer in certain cases. UV rays present in sunlight can prove to very harmful for human skin.

1.3 Solar Radiation

Radiations coming from sun are called solar radiations. Half of the radiations are visible-short wave part of electromagnetic spectrum and other half is mostly infrared part with some of the ultraviolet part of spectrum. Light radiations with longer wavelength 100nm to 400nm and lower frequency than visible light forms. The other part of solar radiation consists of visible spectrum which enables us to see the objects in sun light. Electromagnetic radiation in visible range of wavelengths is called visible light or simply light rays. A typical human eye will respond to wavelengths from about 390nm to 700 nm.

The third component of solar radiations is ultraviolet light which have shorter wavelength than that of visible light, but longer than X-rays, that is in the range 100 nm to 400 nm. An over exposure to UV radiation can lead to sunburns and other skin diseases to humans. UV rays are sub divided into three types namely: UVA , UVB and UVC.

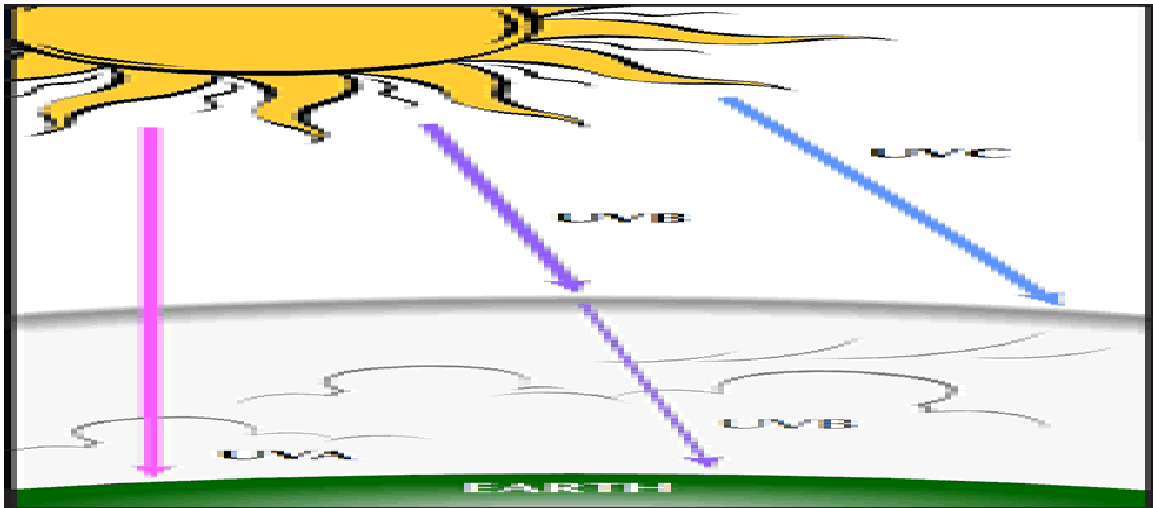


Figure 1.2: Types of UV rays [33]

As shown in figure 1.2 out of three UVB and UBC are absorbed by Ozone layer present in atmosphere but UVA radiations still reach earth surface crossing Ozone layer and cause skin disease to human skin and it has been proved by scientist that UVA radiations are very harmful for human skin and eyes.

1.4 Protection from Sun Glares Effects

Many biologist, dermatologist and engineers are working in the area of sun glare protection for all they are working all day and night in the search of sun glare elimination solution, some of the common instructions for sun glare protections are listed as follows.

- Apply skin protective sun creams.
- Wear UV protective sunglasses or eye lenses.
- While driving car use Sun visor.
- Use Sunscreen.
- Wear full sleeve cloths whenever go out in sun light.

1.5 Passenger Car Sun Visor

In passenger cars for sun shade visor is provided as shown in figure 1.3 normally cars come with two sun visor one is for driver and the one for co-driver. It is made by pressboard material and is placed on upped DLO (day light opening) of the windshield. The visor is attached to the roof with a hinge so that driver can adjust the position of visor manually as per the requirement. This has limited area of glare protection. It is not sufficient to protect driver from direct sun glare and reflection from approaching vehicles. It would be impractical to construct a visor of sufficient dimensions to cover sun glare for all possibilities.



Figure 1.3: Car Sun visor [34]

1.5.1 Flaws in Passenger Car Visor Systems

Conventional sun visor used in passenger cars could not screen out sun light when sun is low in the sky and it is not so effective for all drivers following are flaws of conventional sun visor in passenger car.

- Sun visor that is installed on upper DLO of the front windshield covers only a small portion of the front windshield and it is impossible for such visors to completely screen out the sun light effect.
- When sun is near to the horizon visor could not help driver from sun glare protection.
- The hard metal rod used in visor can cause head injury to driver in sudden collision.
- When driver with shorter height sit with forward positioned seat track near to the windshield in this case visor which somehow is useful to screen out sun glare when sun is high in the sky is of no use for driver positioned near to windshield.
- It has been observed that in the case of driver with taller height sit with most rear position of seat track i.e. at a certain distance from windshield in this case conventional sun visor obstruct driver's field of vision.

1.5.2 Efforts to Overcome Flaws of Passenger car sun visor

To overcome flaws many contemporary techniques are present but almost all techniques are not up to the mark to solve problem. Nowadays many sun visor extensions are available in market assisting driver to have clear vision.

1.6 Sun Visor Extension for sun glare protection

Sun visor extensions as shown in the figure 1.4 are widely used in passenger cars as additional protection from sun glare short height people prefer to use it commonly. These extensions are easily available in market. Many vendors also provide extensions to support driver vision from sun light, reflections from street lights and other vehicles while driving at night. Normally these extensions are clipped on conventional visor and are manually adjusted when required. These extensions are useful to screen out sun glare and reflections but the main drawback of these extensions is manual adjustment which can distract driver resulting in loss of driver's concentration and focus error. So the replacement of conventional sun visor by an automatic visor is very much required.



Figure 1.4: visor extension [35]

CHAPTER 2

LITERATURE REVIEW

In this chapter, critical review in the area of automobile interior and exterior design, driver's field of vision while driving, standards for plastic materials used in passenger car interior and Indian ergonomics has been performed. On the basis of this study, chapter is divided in following sections.

1. Cabin visibility standards for automobile.
2. Glare problem during driving & proposed remedial solution.
3. Materials for automobile interior and visor.
4. Ergonomics data for Indian population.

2.1. Cabin Visibility Standards for Automobile

Considering vehicle safety and manufacturing, worldwide many automobile organizations like SAE (Society of automobile engineers), ARAI etc. are continuously upgrading and bringing out new global standards to design vehicle cabin, interior and exterior.

SAE J1100 [16, 27] recommends set of interior and exterior dimensions for passenger car, multipurpose passenger vehicles and trucks. Worldwide, cabin interior of the vehicles are designed using recommendations given in this standard. According to this standard, it is the manufacture who decides what would be the SgRP (sitting reference point) point of the vehicle. All other dimensions like leg room, head restraint height and driver eye point with reference to SgRP point as recommended in this standard are decided.

SAE J826 [17, 27] applies for vehicle seating accommodation measurements. In this standard driver leg room dimensions like foot positioning, accelerator heel point location are specified with reference to the SgRP point.

SAE J941 [18, 28] this standard applies to motor vehicle driver's eye location with reference to SgRP point. This standard defines driver's forward field of vision area. With reference to 95th percentile Eyellipse (contraction of "eye" & "ellipse" representing driver eye location in road vehicles) the upward sightline angle subtended tangent to the upper portion of Eyellipse is 7° and the downward sightline angle subtended tangent to the lower portion of Eyellipse is 5°.

AIS-021[12, 19] applies to field of vision of vehicle driver for 180° forward field of vision. Except windshield garnish, ‘A’ pillars, rear view mirror and radio aerial there should not be any obstruction for driver’s 180° forward field of vision. In this standard SAE 95th percentile Eyellipse position is referred in order to determine driver’s forward field of vision. With reference to this standard, all automobile manufacturers manufacture vehicles windshield and also design driver’s forward field of vision.

2.2. Glare Problem during Driving and Proposed Remedial Solutions

Driving in a sunny day is very comfortable when compared to weather conditions like rain, fog etc. Sometimes driving in a bright sunny day can also be challenging due to a discomforting sun glare. As discussed in the introduction chapter sun glare affects driver’s vision area which makes a driver to either slow down the vehicle or to stop abruptly because of a sudden blindness. As the sun keeps on changing its position in the sky, hence it’s very important to understand that at what time sun glare effect is maximum.

Hagita and Mori [1] Studied, how sun glare contributes to traffic accidents in Japan. They found that the traffic accident rate tended to be higher when the sun is low and in front of the vehicle, that is near to the horizon at the time of sun set and sun rise. They have performed study on calculating solar position at accident spot as shown in figure below.

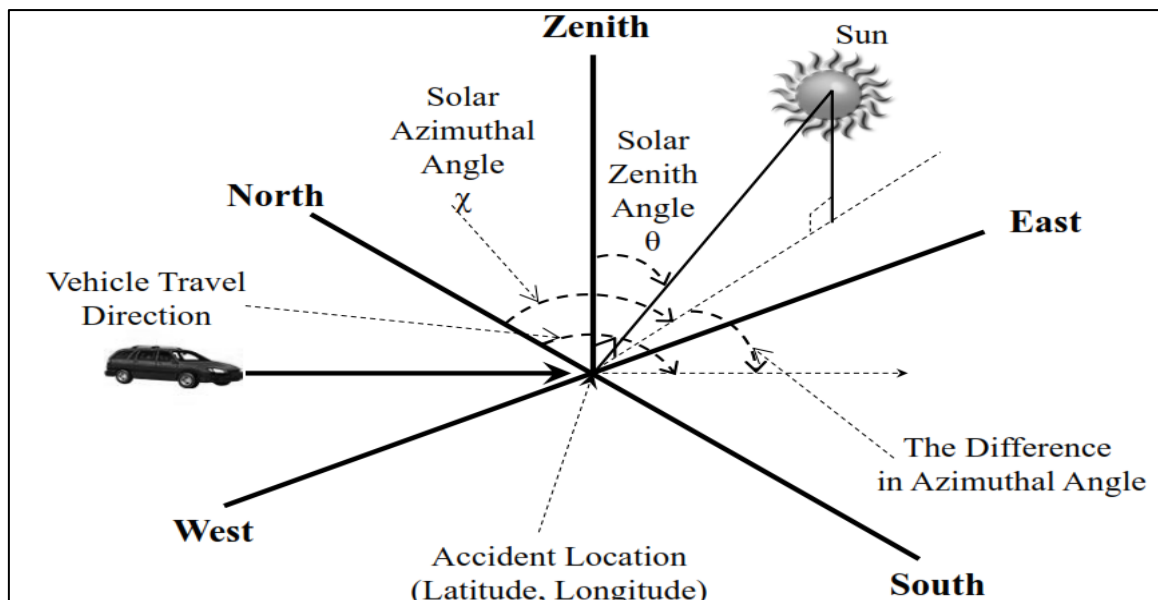


Figure 2.1: Solar position at accident spot [1]

Sun position is represented by zenith and Azimuthal angle. When zenith angle exceed 90° , it is night. Azimuthal angle is the angle between North Pole and the sun position on horizontal plane.

Mitra Sudeshna [2] Studied how adverse weather and sun glare affects traffic operation and safety. Author stated that travelling towards east direction in morning and towards west direction in the evening is susceptible to sun glare related problem.

Sun glare effect is very dangerous at the time of sun rise and sun set. The conventional sun visor in vehicle has limited area of glare protection, which is not sufficient to protect the driver from the direct sun glare and reflection from the approaching vehicles. Many inventions have been done in the area of sun visor extensions. Using these extensions sun glare effect can be effectively reduced.

Elahi and Rahman [22] proposed an automatic sun visor system in automobile. Visor is made automated using stepper motor, temperature sensor and arduino board system. Temperature sensors were placed on car windshield for sensing the intensity of sun light radiations. Then, these sensors actuate stepper motor which accordingly adjust the car sun visor.

Edmund [23] developed a sun visor extension for automotive vehicles to eliminate the sun glare as well as headlights glare of the approaching vehicle. The extension is made by translucent shield of coloured or non-glare material. It is clamped to conventional sun visor. Extension is so designed so that it can retract its position and can conceal in the main visor.

Williams [24] designed an auxiliary glare protection circular shield for automotive vehicles. This shield is attached to conventional sun visor in a channelled track member. It is so positioned, that driver can adjust its position manually to a desired position. On the other side, shield is provided with mirror which can serve the purpose of a rear view mirror or a vanity mirror.

Jerry [25] suggested the use of a transparent sun blindness eliminator for automotive vehicles. It is clamped to the conventional sun visor. It is comprised of three main components, a swivel base, circular disc and a telescopic support. Inventor described that the disc can be manufactured from an opaque, translucent or transparent material such as Mylar, Plexiglas, and Polystyrene. The swivel base is affixed to sun visor. Driver can position the movable circular transparent disc against sunlight glare manually.

Anatoli [26] invented a sun visor which is both pivot able and slid able, so as to provide wide range of adjustment to sun rays. It can also be used at night to shield driver from reflection and headlight glare from approaching vehicles. Visor is provided with pair of tracks clamped to conventional sun visor in vehicle. Two glare panels are so provided so that one can protect driver from sun rays and another can shield driver from headlight glare from an approaching vehicles.

From this study, it is concluded that, sun glare problems do occur when sun is in front of the vehicle. Various inventions have shown that, it is possible to screen out sun glare effect using anti-glare screens.

2.3 Materials for Automobile Interior and Visor

Plastic materials are widely used in automobile industry to reduce the weight and cost, provide high performance, corrosion resistance & durability. Following section shows the use of suitable standardized plastic material in automobile industry.

Szeteiova [3] presenting the use of plastics in an automobile industry. 50% of different type of all the interior components of a vehicle including the doors and the seats comprises of plastic materials like Polypropylene, Polyurethane, Poly-vinyl-chloride, Acrylonitrile-butadiene-styrene, Polyamide, Polystyrene, Polyethylene, polycarbonate, PMMA, POM, ASA and etc.

AIS-118 [20] standard applies for automotive vehicle- safety glazing material .According to this standard plastic materials used in the vehicle for glazing purpose should have 70% of transmittance and $90\text{mm}/\text{min}$ of burning rate.

ASTM D638 [21] standard provides mechanical properties of plastic materials like polypropylene, Acrylic and etc.

Vietro et al. [4] proposed a transparent, less reflective and a scratch resistant polycarbonate material for automobile applications.

Walley et al. [5] exhibited the use of highly transparent polycarbonate plastic material in automobile industry. Polycarbonate material is sandwiched between glass materials because of high transparent property of polycarbonate material. This combination is used for making bullet proof windshield for automobile vehicle.

Noborisaka et al. [6] studied the use of SiOC(-H) thin films on polycarbonate plastic material used for vehicle window. This study revealed that appropriate use of this film gives 100% optical transparency and good material hardness.

Citek [7] also emphasized that the antireflective properties of polycarbonate plastic material are better than other plastic lens materials like Trivex, crown glass and etc. Ashori [8] proposed wood-plastic as promising green-composites for automotive industries.

Du et al. [14] worked to determine ZnO nanohole and nanowire array structures for UV-blocking anti-reflective coating. In modern optical highly transparent anti-reflective coatings are required to protect the devices from UV blocking. ZnO has the property of blocking UV rays and has high transparency in the visible range.

Sain et al. [15] investigated that using Polypropylene composite containing magnesium hydroxide improves flame retardant property of Polypropylene with marginal reduction in mechanical property.

2.4 Ergonomics Data for Indian Population

Nowadays, automobile industry emphasizes more on the ergonomically designed product. People from different countries possess different body configuration & sizes. These variations make it very important, that for a particular country, ergonomics data for that country should be considered. Dr. Day Chakrabarti [28] studied the Indian anthropometric dimensions of males and females in the sitting as well as in the standing posture for ergonomics design practice. Descriptions are given from minimum to maximum percentile i.e. 5th to 95th percentile data.

2.5 Conclusion

From the literature review, it is concluded that it is possible to screen out the sun glare as well as the headlight glare from approaching vehicles using visor extensions made up of antiglare material. Most of the reported work deal with the area of sun visor extensions but no work has been done in the field of redesigning of conventional sun visor. Hence, it is very much required to consider the redesigning to the existing sun visor with the one which can overcome all the flaws of the existing conventional sun visor & also has the capability to be automated.

CHAPTER 3

CONCEPTUAL DESIGN OF VISOR SYSTEM

As presented in the previous chapter, automobile parts should be standardized and ergonomically designed. Proposed sun visor system in the present study has been designed in accordance with automobile standards and Indian anthropometric data.

3.1 Design Constraints

Following design constraints have been employed in the present study.

1. First constraint is the selection of car model. Different cars have different cabin configuration & sizes. Methodology presented in this study can be extended to any passenger car, if the car interior cabin dimensions are known. Data for car dimensions has been extracted from Porsche engineering services [29]. Data is available on 'WorldAutoSteel' website.
2. Second constraint is ergonomic data. Nowadays, automobile industry emphasizes more on the ergonomically designed product. People from different countries possess different body configuration & sizes. These variations make it very important, that for a particular country, anthropometry data for that population set should be considered. In this study Indian anthropometry data has been used. The data has been borrowed from Indian institute of technology Guwahati's website [28].

3.2 Design Parameters

Two design parameters i.e. visor throw length and width of the anti-glare sheet has been decided on the basis of above mentioned design constraints i.e. automobile standards and Indian anthropometry data available. Throw length of the visor is the maximum length of the anti-glare sheet, which will come out of the visor casing. Width of the anti-glare sheet is the maximum width by which the visor will protect the driver from sun light from different angles. Methodology for these two dimensions for given design constraints are discussed below.

3.3 Throw Length of Visor

Main aim of this study is to aid the small height driver to see clearly irrespective of sun glare. In figure 3.1 two views profile view and top view of a car model are shown. In any given population anthropometry data, there are variety of sizes, ranging from population minimum to population maximum. Figure 3.1 Eyellipse positions of the taller, average & smaller driver

of the selected population set. It is clear that small height driver's sit closer to the windshield due to inherent ergonomic detail & would have more exposure to sun light than taller driver. By taking note of this fact, the visor length is calculated for the small height driver, which is automatically suitable for taller driver.

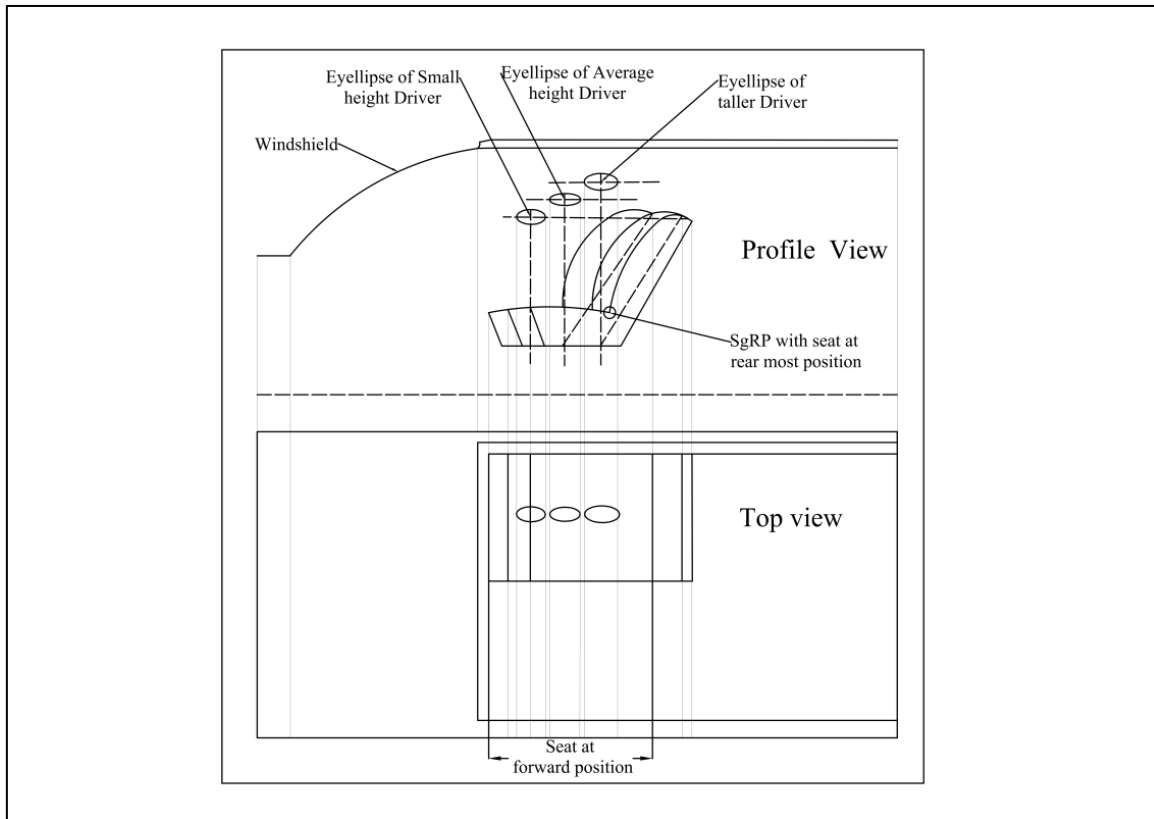


Figure 3.1: Eyellipse position of small, average and tall height driver in side and top view

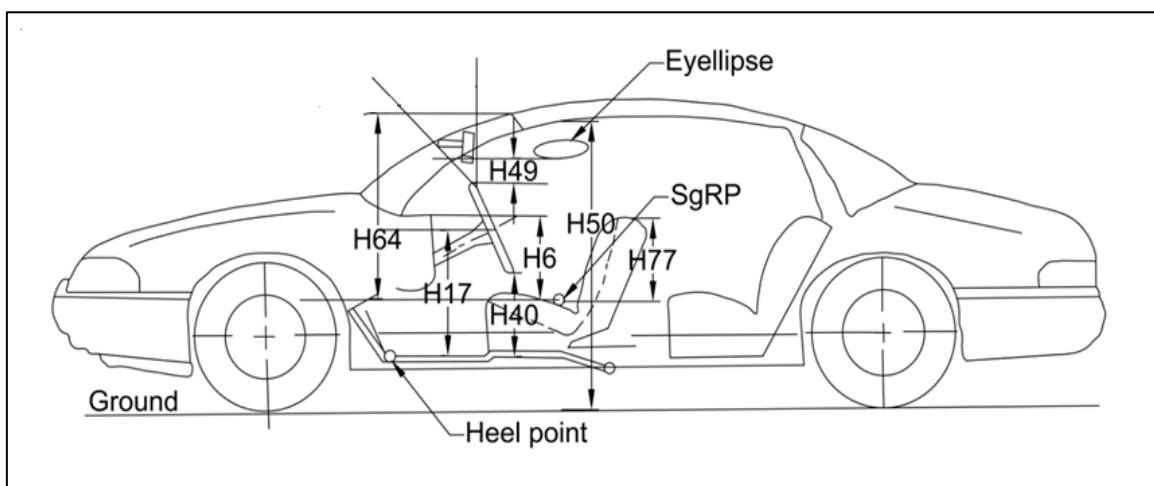


Figure 3.2: Driver's cabin height dimensions [16, 27]

3.3.1 Passenger car cabin design terminologies

As discussed before an automobile part should be designed as per the design standards. In this study SAE standards for passenger car interior design has been followed. In SAE J1100

[16, 27] terminologies related to the vehicle cabin design have been described. These terminologies are used worldwide for vehicle cabin design. Car model used in this study is designed as per these terminologies. Figure 3.2 shows relevant automobile terminologies for automobile vehicle cabin's height dimensions, which are defined below:

SgRP = Sitting reference point. It is the point which is decided by the manufacture & is used as manufacturers design reference point.

Eyellipse = It represents a 95th percentile eyellipse as described in SAE J941 [18, 27].

Heel point = It is the position of driver's heel point.

H 6 = SgRP front to windshield lower DLO (day light opening) distance.

H17 = Accelerator heel point to steering wheel center.

H40 = Steering wheel to accelerator heel point distance.

H49 = Eyellipse to the top of the steering wheel distance.

H50 = Upper-body opening to ground-front distance.

H64 = SgRP-front to upper DLO (day light opening) distances.

H77 = Seat-back height driver.

Passenger car cabin is designed according to these terminologies. SgRP point is decided by the manufacturer and all other dimensions are decided in reference to SgRP point [16, 27]. There are also some terminologies for cabin's length dimensions. Figure 3.3 shows terminologies related to length dimensions.

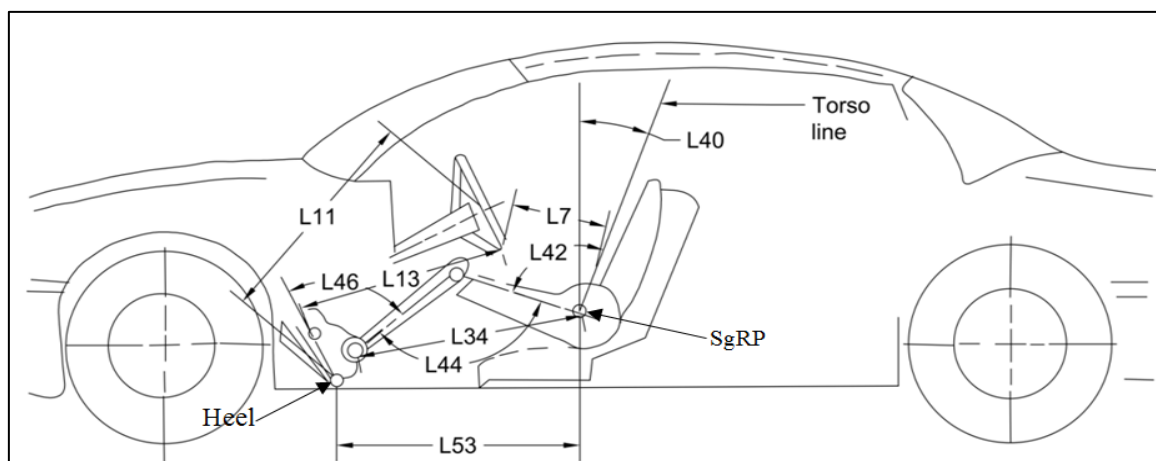


Figure 3.3: Driver's cabin length dimensions [16, 27]

Terminologies for horizontal dimensions are as explained below.

Torso line = Torso line is the line in the two-dimensional drafting template connecting the shoulder reference point and the SgRP point.

L7 = Steering wheel to torso clearance distance.

L11 = Accelerator heel point to steering wheel centre distance.

L13 = Brake pedal to knee clearance distance.

L34 = Effective leg room-front.

L40 = Torso back angle-front.

L42 = Hip angle-front.

L44 = Knee angle-front.

L46 = Foot angle-front.

L53 = SgRP to heel point length.

3.3.2 Passenger car cabin design

As discussed before the aim of this study is to calculate the throw length of the visor to effectively protect small height driver from sun light exposure while driving. Various dimension & terminologies discussed in figure 3.2 & 3.3 have been used for drafting the side view of the car model to show the **SgRP** point as shown in figure 3.4. Measurements for these terms have been borrowed from the available car model [21] and important dimensions used in this work are given in table 3.1.

Table 3.1 Car interior dimensions [29].

Symbol	Definitions	Measurements
H6	SgRP – front to windshield lower DLO	495mm
H64	SgRP – front to windshield upper DLO	796mm
H61	Effective head room – front	1019mm
H122	Windshield slop angle	59°
L53	SgRP – front to heel point	832mm
W9	Steering wheel maximum outside diameter	370mm
W7	Steering wheel center – Y coordinate	350mm
W20	SgRP front to Y coordinate	350mm

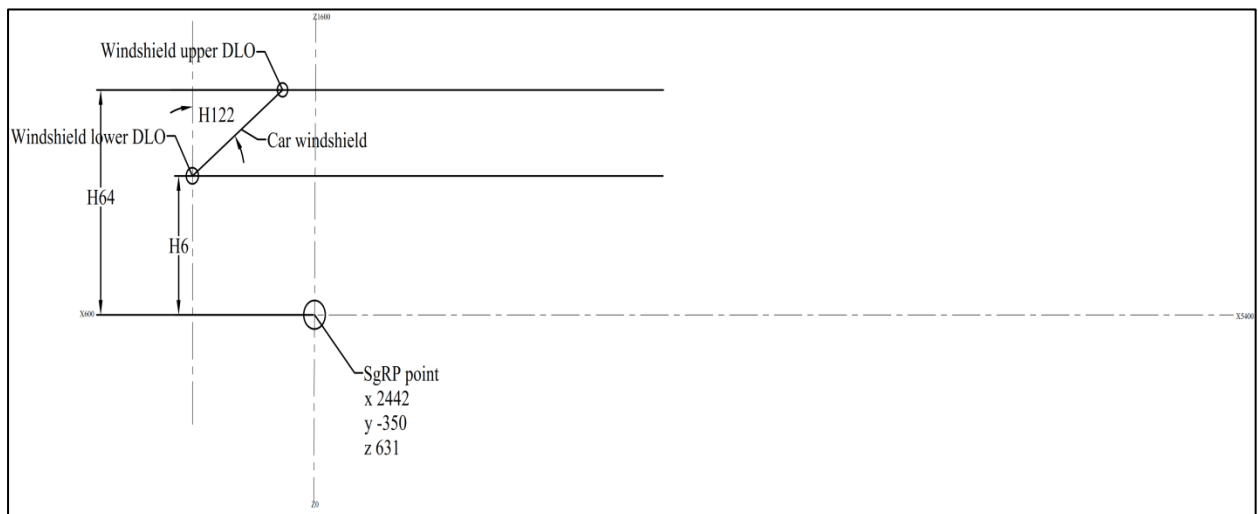


Figure 3.4 SgRP point location in xyz coordinate system

The dimensions for creating the figure 3.4 are as mentioned in table 3.1. Three dimensional SgRP point is the manufacture seating reference point used as the basis for finding the values of other required dimensions for vehicle cabin design. In the present work all required dimensions for the development of sun visor system have been plotted with reference to this point like the location of Eyellipse points for the driver.

3.3.3 Determination of location of Eyellipse points

Indian anthropometric data has been used for locating driver's eye point. Dr. Day Chakrabarti [28] performed studies & generated data related to Indian population for ergonomics design practice in vehicle cabin design. In present study two dimensions i.e. E_{tl} (eye point template location) & B_{ecl} (Buttocks to extended leg comfortable length) have been used for accommodating driver in figure 3.4. E_{tl} is used for locating drivers eye points vertically & B_{ecl} is used for locating drivers eye points horizontally as shown in figure 3.1. Figure 3.5 shows the height dimension from buttocks to the inner corner of the eye. Further the E_{tl} values for Indian male and female population data is presented in table 3.2.

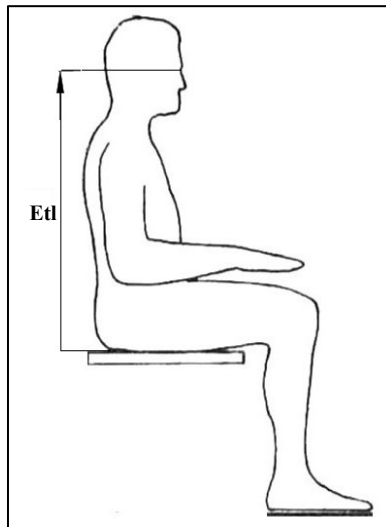


Figure 3.5: Eye point template location (E_{tl}) in sitting posture [28]

Table 3.2: Eyellipse template location (E_{tl}) data for Indian population (in mm) [28]

	Min	Percentile					Max	Mean	σ
		5 th	25 th	50 th	75 th	95 th			
Male	570	678	709	738	760	805	867	738	39
Female	515	574	628	653	686	731	762	657	45
Combined	515	623	686	723	751	796	867	716	54

According to SAE [16] standard passenger cars must have horizontal forward seat track of more than $100mm$. Car model used in this study has seat track length of $240mm$. As discussed before body configuration and sizes differ from people to people. In figure 3.1 it is clear that small height driver sit closer to the car windshield to get ease control over brake, clutch and accelerator pedal and also to have clear vision. For this driver has to move driver seat in forward direction horizontally. Figure 3.6 shows buttock to extended leg comfortable length (B_{ecl}) human sitting posture.

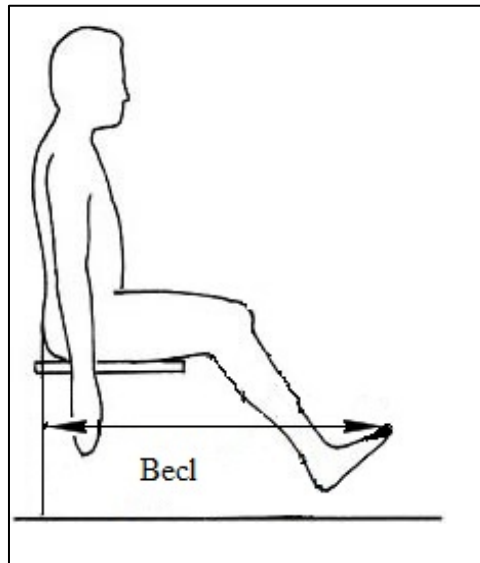


Figure 3.6: Buttock to extended leg comfortable length (B_{ecl}) [28]

B_{ecl} Values for Indian male & female population data is given in table 3.2.

Table 3.3: Buttock to extended leg comfortable length (B_{ecl}) for Indian population (in mm) [28]

	Percentile								
	Min	5 th	25 th	50 th	75 th	95 th	Max	Mean	σ
Male	685	758	869	923	989	1086	1210	926	98
Female	660	719	809	851	904	979	1086	852	78
Combined	660	739	849	905	979	1069	1210	910	99

For 95th percentile data the difference of B_{ecl} length for male and female is $107mm$. It means that female drivers have to move $107mm$ forward as compared to attain comfortable sitting posture.

In SAE J826 [10] standard SgRP point location on human body template is given. Figure 3.7 shows the SgRP point location on human body template. All dimensions are in mm. H-point is the sitting reference point. Buttock to H-point length is $97.6mm$. This length is for 95th

percentile passenger car drivers irrespective of male and female driver. In table 3.2 length data from buttock to inner corner of eye is given. By subtracting 97.6mm this length is calculated again for 95th percentile male and female.

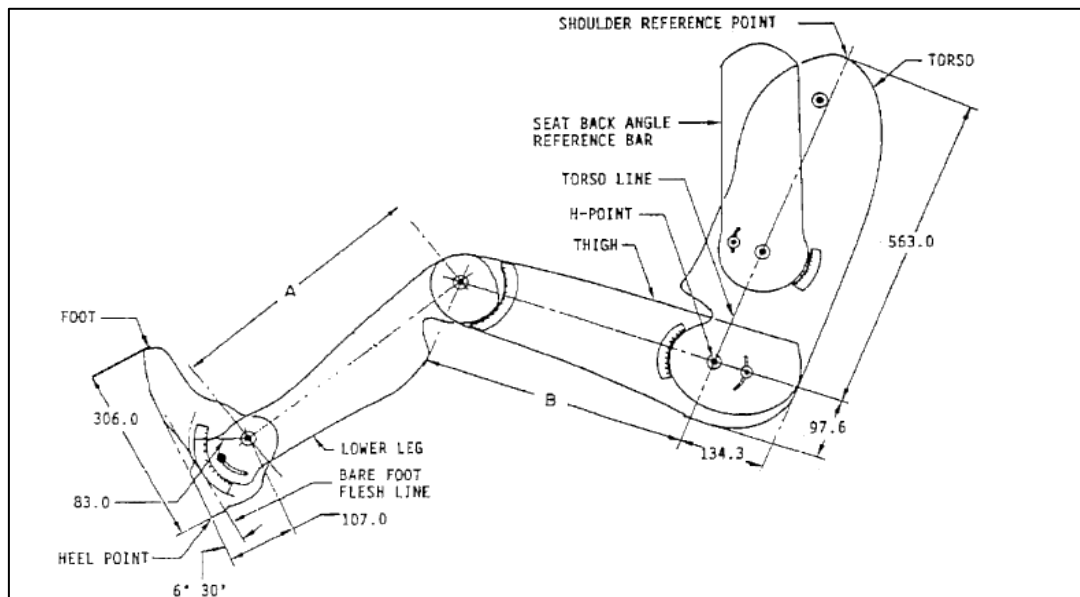


Figure 3.7: H-point template for 95th percentile passenger car driver [17]

Using above discussed study top and profile view of the available car model is shown in figure 3.8. Modelling has been done in Pro-E CAD modelling software's sketcher module. Point 'P' lie on a horizontal line passing through top and profile view of passenger car.

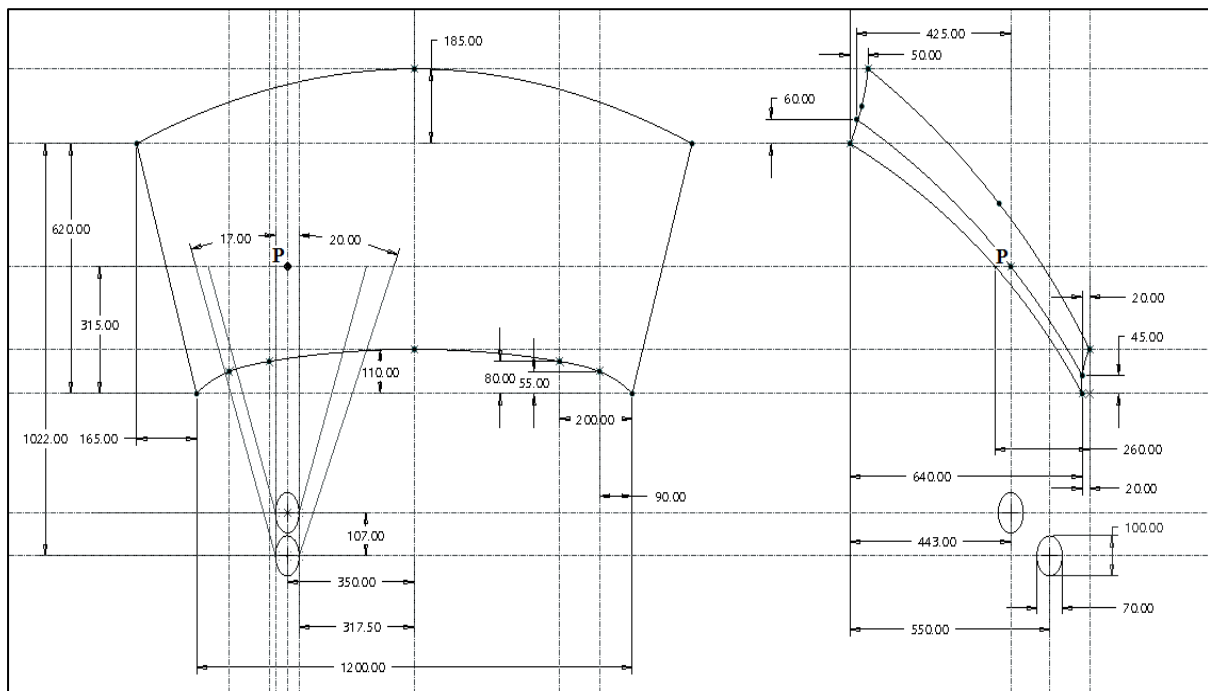


Figure 3.8: 'P' point location in top and profile view

Dimensions are approximated from the available grid size of the car model. Figure 3.9 shows the grid size of the available car model. Grid size is 100mm drawn to same scale. It can be seen from the sketch that the distance between Centre line and 'A' pillar covered by six vertical lines which means that the value of this distance is 600 mm approx. Ellipsoid of 95th percentile male and female driver has been accommodated in this car model using Indian anthropometric data.

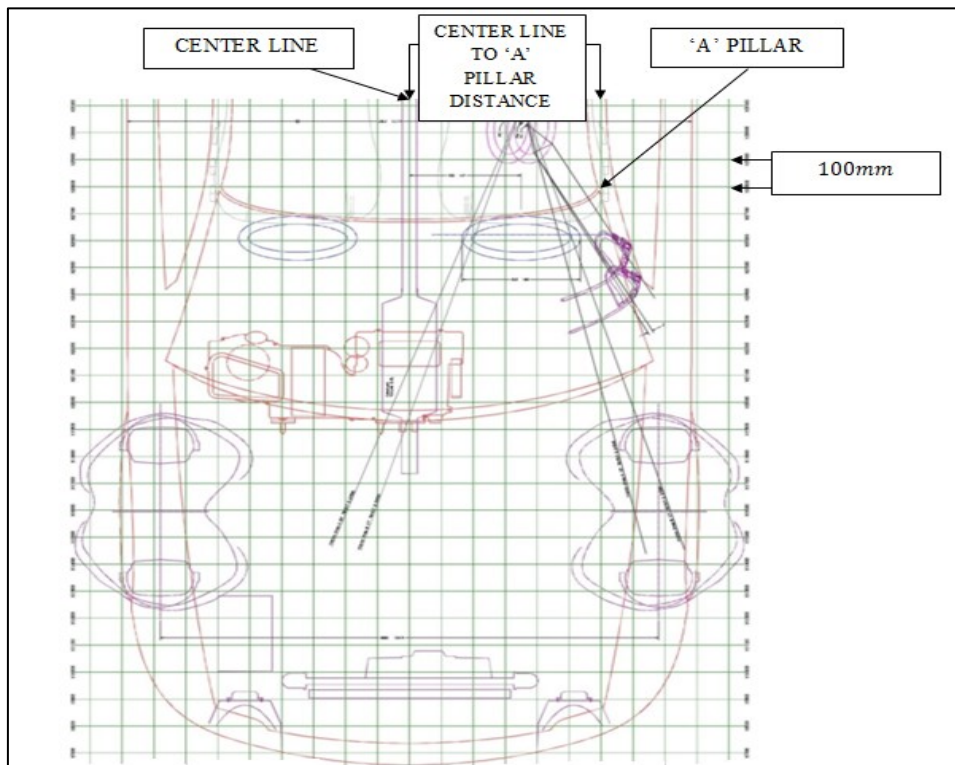


Figure 3.9: Top view of an available car model [29]

Through length of the visor has been calculated by accommodating male and female driver eye point in profile view of the available car model as shown in figure 3.10. Point 'p' is calculated as shown in figure 3.8.

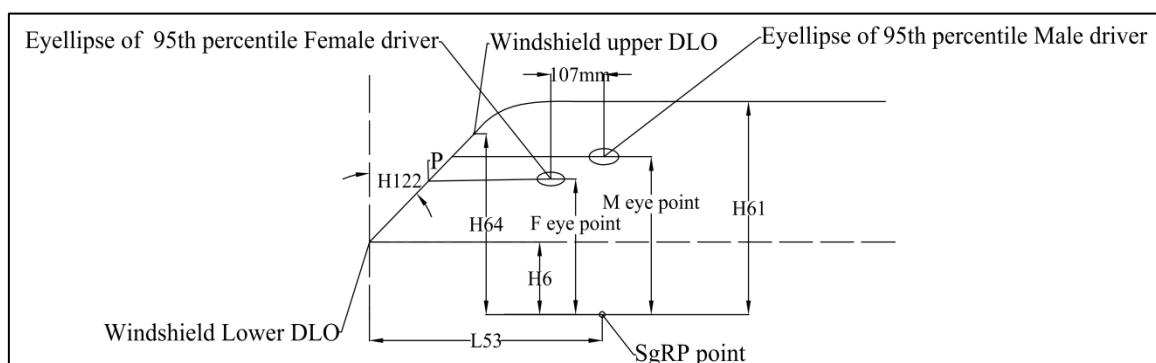


Figure 3.10: Eye point location of female and male driver in profile view

Calculated through length of visor for male driver is shown in figure 3.11(a). Upward and downward vision area is marked starting from eyellipse by 7° upward angle and 5° downward angle of vision.

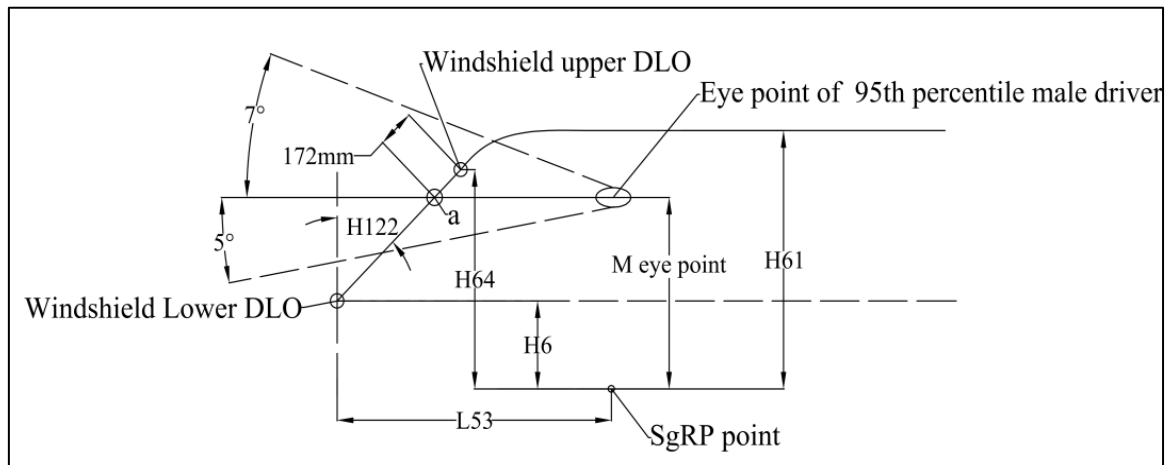


Figure 3.11(a): Visor through length calculation for 95th percentile Male driver.

A horizontal ray is drawn from Male driver's eye point which intersects with the car windshield at point 'a'. The length between point 'a' and upper DLO of the windshield is the calculated throw length of the visor for male driver. The calculated throw length of the visor is 172mm. calculated through length for female driver is shown in figure 3.11(b). Upward and downward vision area is marked starting from eyellipse by 7° upward angle and 5° downward angle of vision.

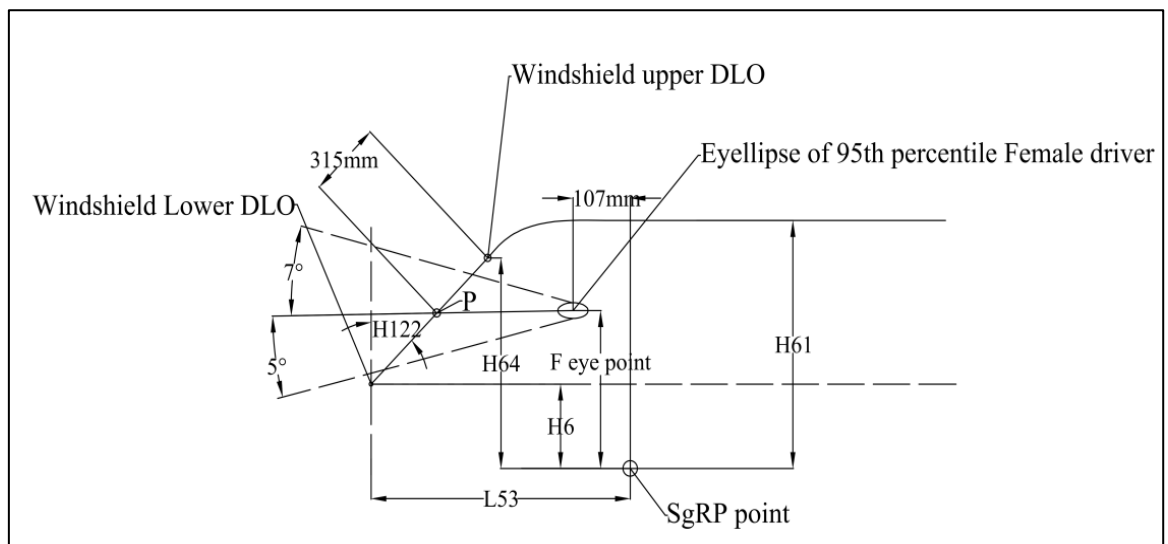


Figure 3.11(b): Visor through length calculation for Female driver.

A horizontal ray is drawn from Female driver's eye point which intersects with the car windshield at point 'P'. The length between point 'P' and upper DLO of the windshield is the

calculated throw length of the visor for female driver. The calculated throw length of the visor is 315mm.

3.4 Width of the Sheet

As discussed earlier small height driver has to sit closer to windshield. In order to effectively operate the controls however this sitting position makes the driver more exposed to sun light. It can be clearly seen from figure 3.1 that the small height driver is subjected to maximum sun light exposure. By keeping the note of this fact, the sheet size is calculated to protect small height driver from sunlight at wide vision angles & it shall be automatically suitable for taller driver. Standard SAE width dimensions terminologies are shown in figure 3.12.

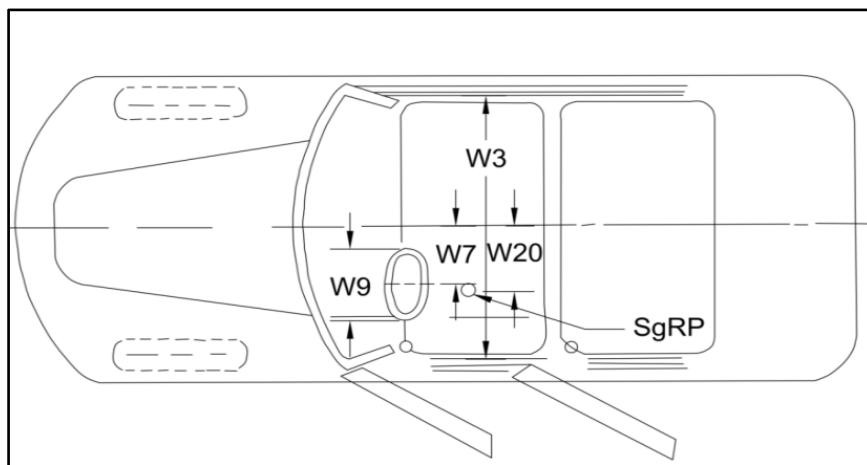


Figure 3.12: Driver cabin width dimensions [16].

Various terms are defined below.

SgRP = Sitting reference point it is the point which is decided by the manufacture. This is its design reference point.

W3 = Shoulder room front.

W7 = Steering wheel centre to Y coordinate distance.

W9 = Steering wheel maximum outside diameter.

W20 = SgRP front to Y coordinate distance.

Using these terminologies, anthropometry data and the measurements from the available car model width of the anti-glare sheet has been calculated. Figure 3.13 shows eye point location of 95th percentile female and male driver. 'P' point line is the horizontal line drawn from profile view shown in fig 3.8.

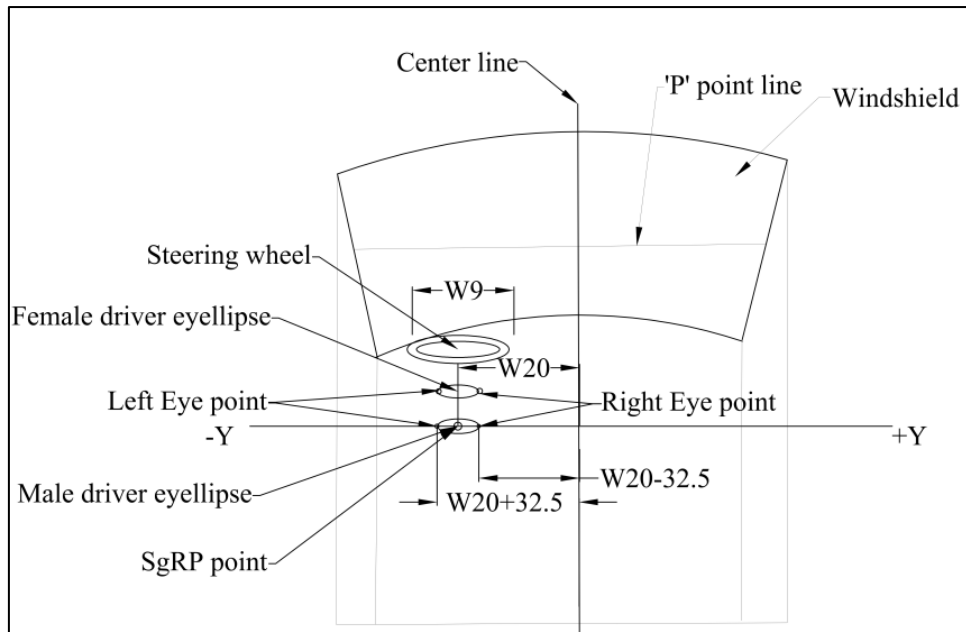


Figure 3.13: Eye point location of female & male driver in top view

Left and right eye points are calculated as per SAE j941 [18] standard. 20° right and 17° left are drivers vision angles [29]. Right and left vision area is marked starting from Eyellipse by 20° right side and 17° left side angle of vision. Figure 3.14(a) shows calculated vision area for 95th percentile female driver. A ray is drawn at an angle of 17° from left eye point which intersect windshield at point 'b'. A ray is drawn at an angle of 20° from right eye point which intersect windshield at point 'c'. Point 'b' and 'c' lie on horizontal 'p' line which is drawn from the profile view of the car model shown in figure 3.8. The length between point 'p' and 'q' is the calculated width length of the sheet for female driver, which comes out 445 mm denoted by W_f .

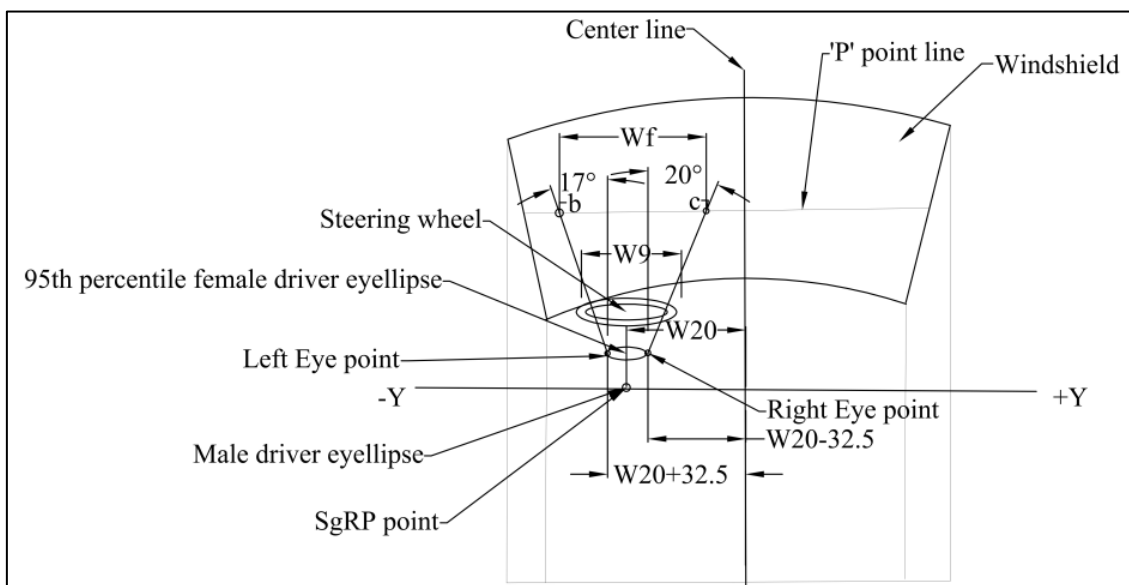


Figure 3.14: (a) Calculated width for female driver.

Now, for 95th percentile male driver the calculated visor length is shown in Figure 3.14(b) shows calculated vision area for male driver. A ray is drawn at an angle of 17° from left eye point which intersect windshield at point 'b'. A ray is drawn at an angle of 20° from right eye point which intersect windshield at point 'c'. Point 'b' and 'c' lie on horizontal 'p' line which is drawn from the profile view of the car model shown in figure 3.8. The length between point 'p' and 'q' is the calculated width length of the sheet for male driver, which comes out 553 mm denoted by W_m .

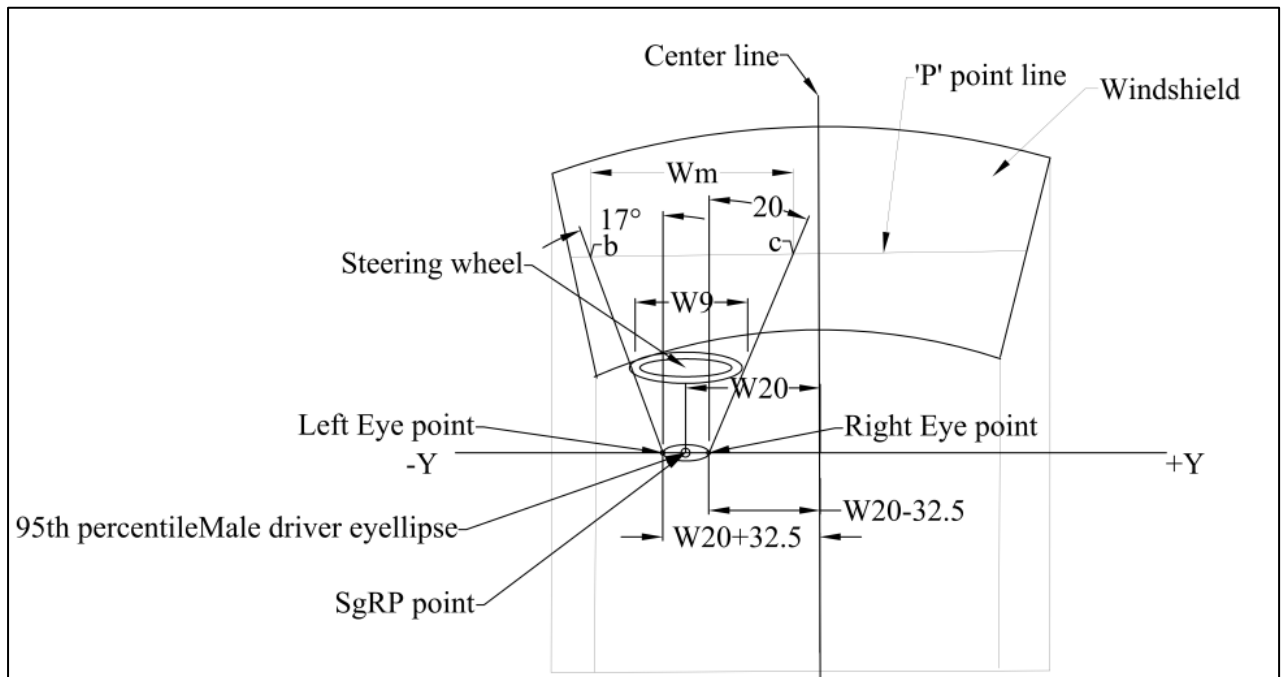


Figure 3.14: (b) Calculated width for male driver

Width of the dimension has been decided 553 mm.

CHAPTER 4

DESIGN OF COMPONENTS AND MATERIAL SELECTION

Designing a component involves perceiving the conceptual design, modelling followed by analysis. Subsequently several design iterations may be required to satisfy the functional requirements of the product. Once the design is finalized, the initial prototype may be realized using Rapid prototyping techniques using CAD solid model [9, 10, 12]. For mass production of the plastic part injection moulding is the most prominent process [11, 13]. In previous chapter important dimensions i.e. through length and width of the visor has been calculated. In this chapter design of other components and mechanical analysis of key components has been done. Designing a new product is an iterative process. Several iterations have been performed in finalizing the geometry details and sizes of various components involved. Finalised design has been presented in this chapter. Prevalent to automobile industry standards have been followed in the design procedures. All parts are modelled/drafted in Cero elements/Pro 5.0. Material selection for various components has been done on the basis of available automotive standards for plastic material used in passenger car cabin. It has come in mind that, if the conventional visor is replaced with an anti-glare sheet, which would come out of a casing placed attached to the car roof, where the conventional visor is placed in passenger cars. The system can be controlled using push button like the way car power windows are controlled. Considering all these factors visor system has been modelled. Assembly of the modelled visor system is shown in figure 4.1. The parts are shown assembled in main casing. The anti-glare sheet is fixed in the sheet holder using rivets. Protrusions are provided on the side walls of the holder. These side protrusions hold wheel pin. These wheels are rolling in channels provided on the side walls of the main casing. These wheels are used for smooth rolling friction and to give to and fro motion to sheet. Ribs are designed on sheet holder and main casing to strengthen them. Two rollers are mounted at the bottom of the sheet holder. These rollers are used to avoid sagging and lateral movement of the sheet. Two protrusions are provided on the main casing, rollers will rolling over these protrusions. Four pair of protrusions is provided on the front wall of the main casing. Eight rollers are push fit in these protrusions using steel pins. Purpose of these rollers is to avoid sagging and lateral movement of the sheet. A slot is provided in between these rollers. Sheet moves in and out through this slot. Belt and pulley arrangement is actuated using a DC motor. Motor and pulley mountings are mounted on the main casing. Exploded view of the assembly is shown in figure 4.2.

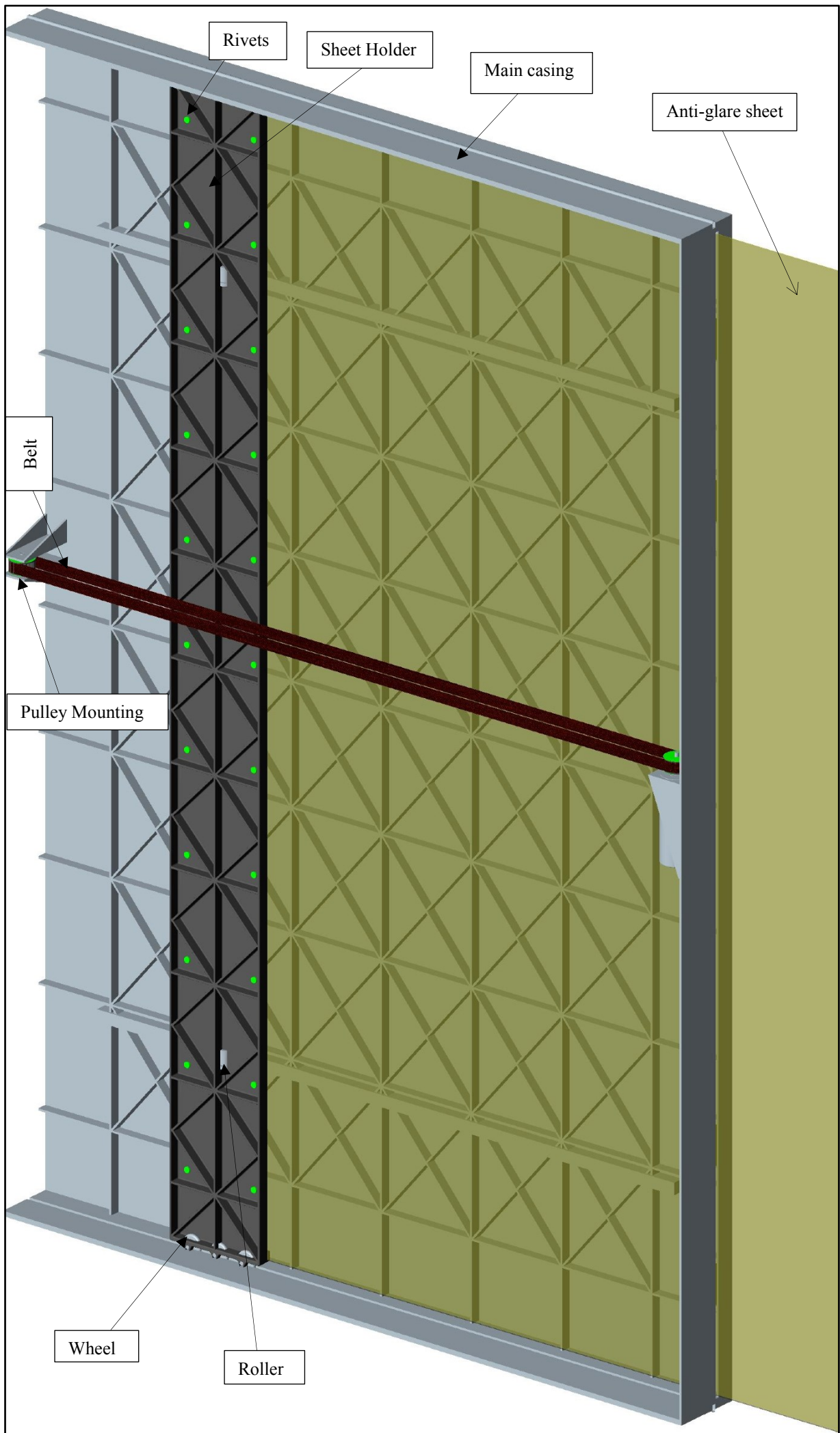


Figure 4.1: Visor assembly

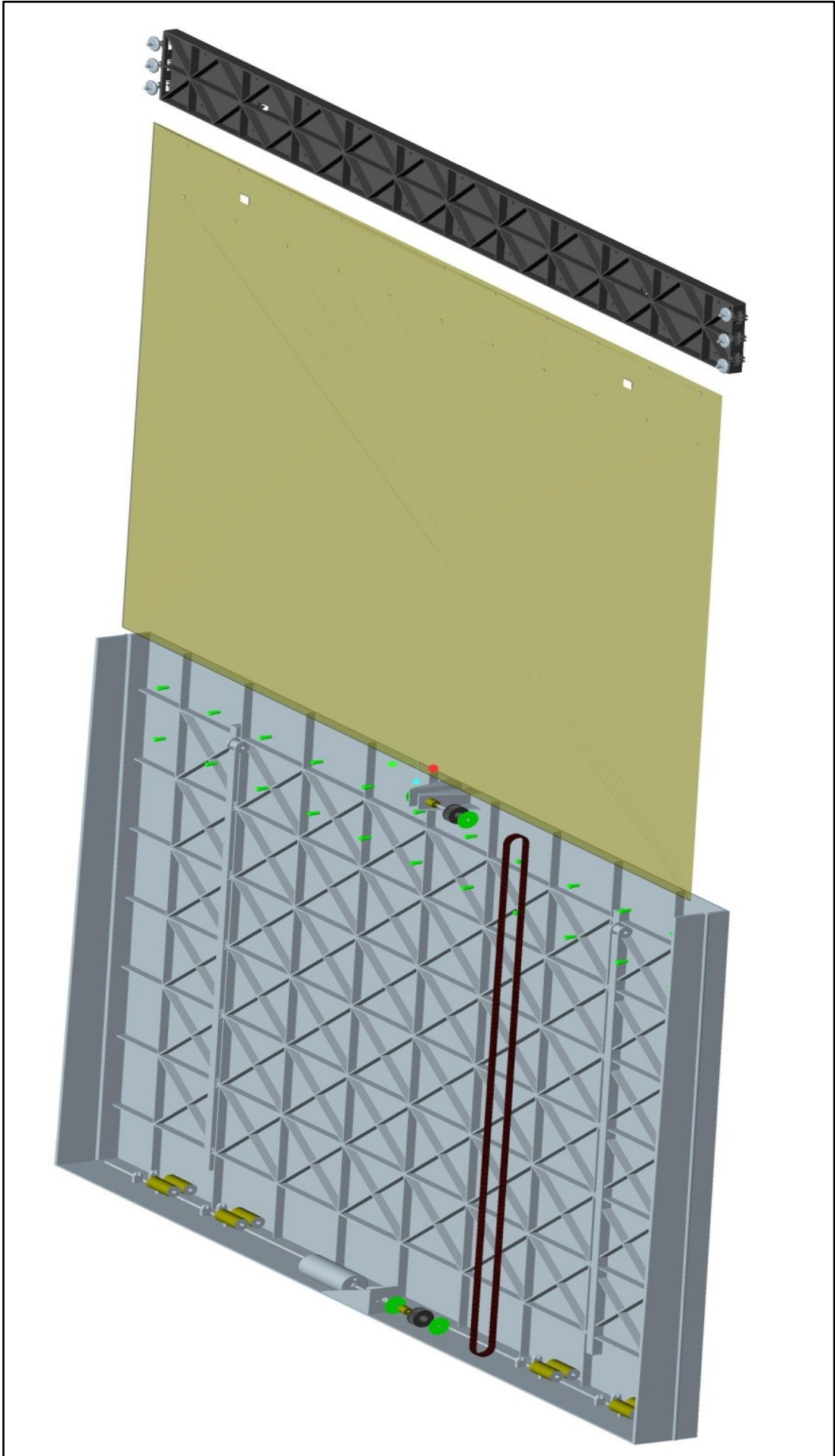


Figure 4.2 Exploded view

Main components of the sun visor model are listed below.

1. Anti-glare sheet.
2. Sheet holder.
3. Wheels.
4. Roller.
5. Main casing.
6. Casing cover.

Design and material selection for these components are explained one by one in the following discussion.

4.1 Anti-glare Sheet

This is the main component of visor. Nowadays, many vendors are selling anti-glare plastic sheets. These sheets are used in vehicles to eliminate/minimize sun glare effect in the morning & evening time and head light glare effect of approaching vehicle at night.

There are many plastic sheets like polycarbonate material, acrylic material; Pvc, trivex etc. are widely available. Polycarbonate material is selected. Because of high transparency, nowadays, polycarbonate material is widely used in automobile industry for making car windows. Its transmittance is more than 70% [4]. It is lighter than glass material. Many vendors are selling anti-glare car sun visor extensions made by polycarbonate material [38]. Polycarbonate is a UV protective material. It has good mechanical properties. Its important mechanical properties are mentioned in table 4.1 below.

Table 4.1 Mechanical properties of polycarbonate material [8, 36]

Mechanical property	Value
Density	1.22 g/cm^3
Poisson ratio	0.37
Young's modulus	2.8 GPa
Tensile strength	55 MPa

Sheet drawings are shown in figure 4.3. Width of the sheet is $d_4 = 553mm$, calculation for width dimension has been discussed in previous chapter. Total length of the sheet is $315 + 50 = 365mm$, 315 is the calculated through length of the visor and 50 length of the sheet is fixed in sheet holder. Thickness of the sheet is $d_0 = 0.7mm$. Polycarbonate sheet is available in wide ranges of thickness [36]. Initially 1mm thick sheet has been used. In order to finalize the sheet thickness, sheet deformation analysis has been performed in Pro-E CAD software's pro-mechanica module.

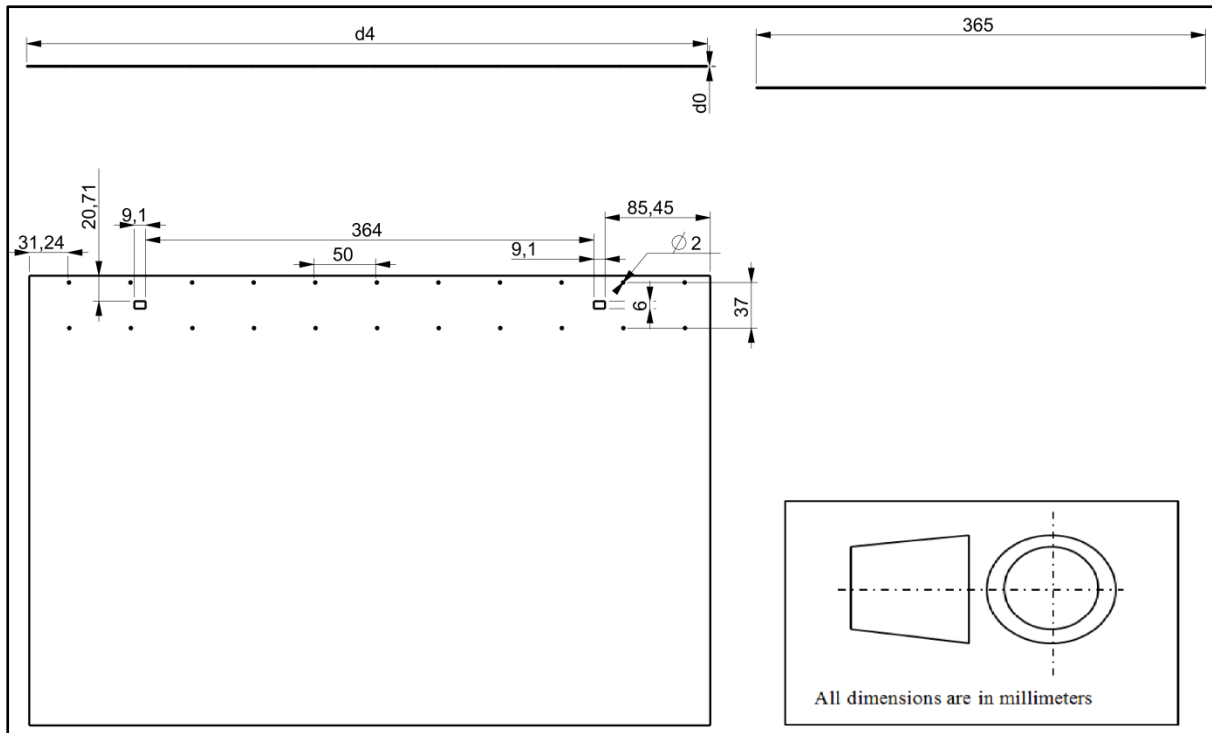


Figure 4.3: Polycarbonate sheet drawings

It is assumed that, if somebody tries to stop the anti-glare sheet to come out of the casing, while the push button is pressed, then the sheet should not deform because of resistance. For this sheet deformation analysis has been performed. Assumed force of 10 N is applied on the front face of the sheet and sheet is constrained by fixed support from opposite side as shown in figure 4.4.

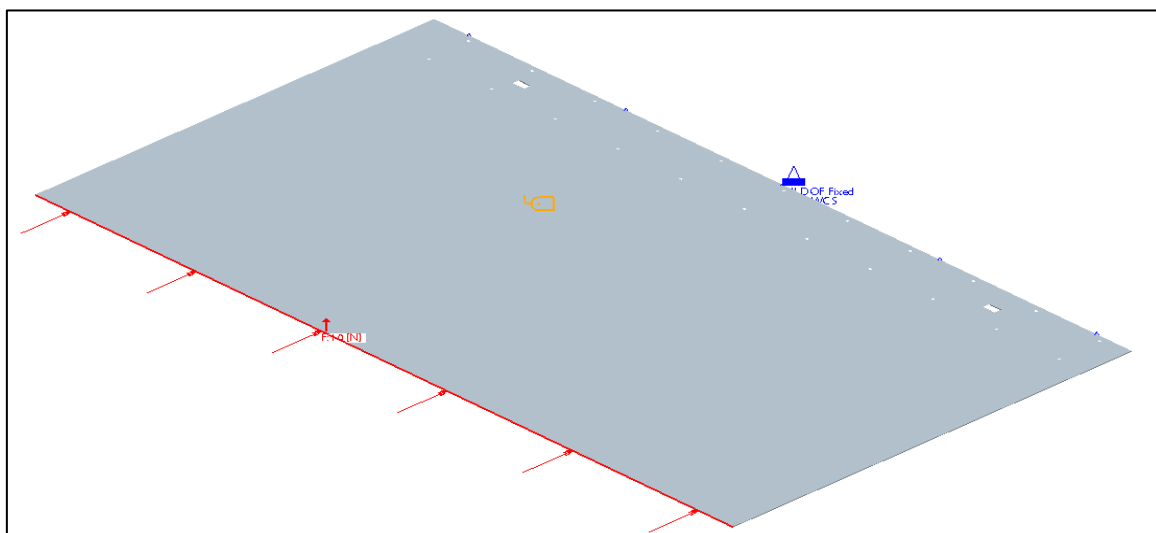


Figure 4.4: Applied force direction and fixed support.

Stresses produced and sheet deformation results are shown in figure 4.5. Stress produced in the sheet part is within permissible limit and deformation is negligible.

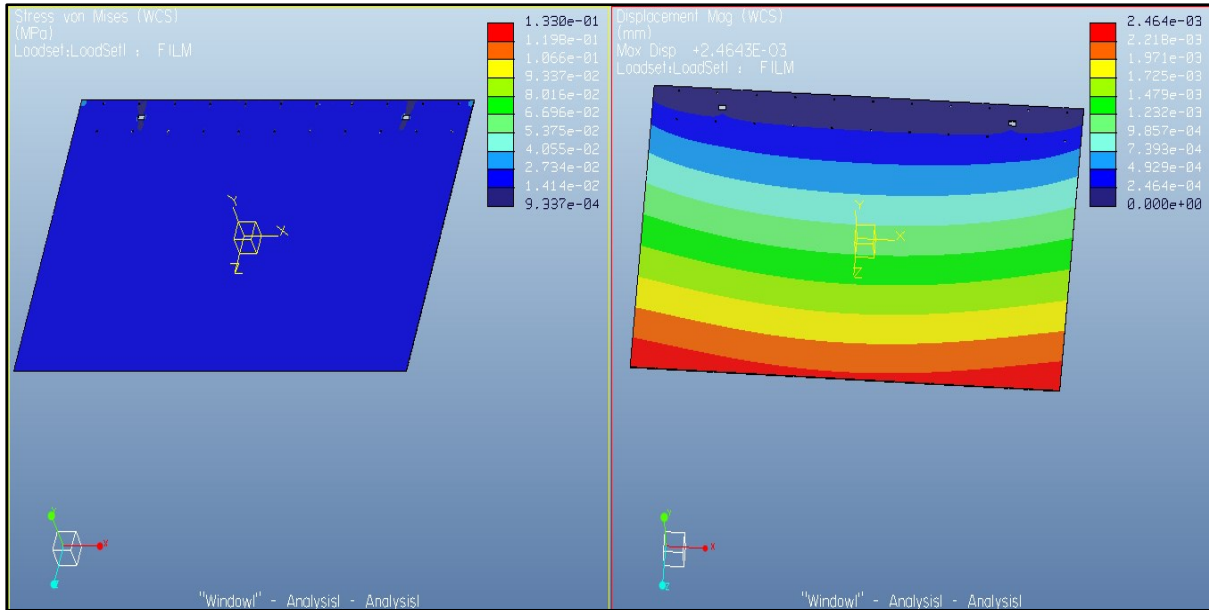


Figure 4.5: Stress and deformation result of 1mm thick sheet.

Stress value in sheet is within permissible limit. Sensitivity analysis has been performed to check the stresses and deformation values of sheet varying d_0 dimension of the sheet from 0.5mm to 1mm. Sensitivity analysis results are shown in figure 4.6. Where, d_0 is the sheet thickness dimension.

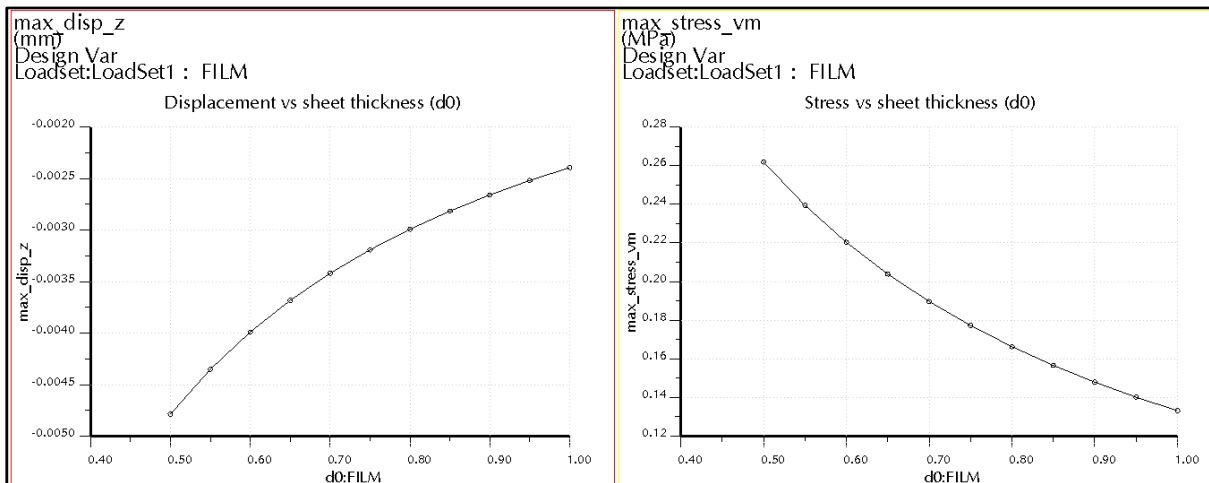


Figure 4.6: Results for sensitivity analysis of Sheet thickness (D0) with respect to displacement and stress values under 10N force

It is clear from this study that, the stress value is within permissible limit and displacement is also negligible even for 0.4 mm thick sheet. Sheet thickness of 0.7mm has been decided as this value is near to the available thickness in market [36]. As the length and width of the sheet is big and thickness is small, self-weight deformation analysis has been performed in order to check deformation due to gravitational force. Results are shown in figure 4.7.

Maximum displacement due to gravitational force is 0.22248 mm , which is very less and acceptable.

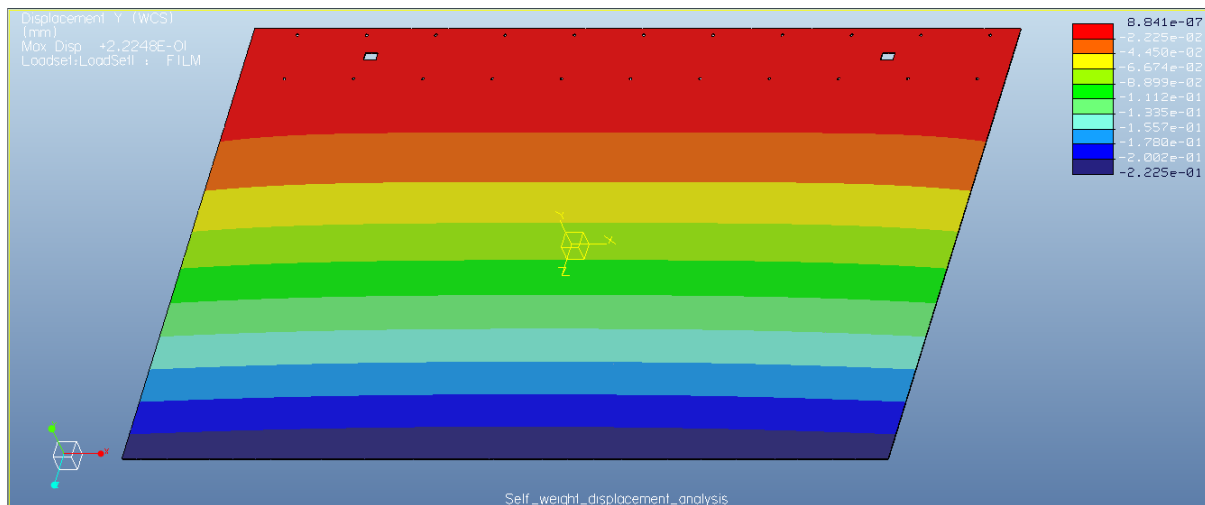


Figure 4.7: Anti-glare sheet self-weight deformation results applying gravitational force analysis

4.2 Sheet Holder

A sheet holder is designed for anti-glare sheet to hold the sheet in main casing. Sheet is fixed in the holder using rivets. Nowadays, plastic materials are widely used in automobile industry, because of light weight, low cost and high mechanical strength [3]. Polypropylene is the selected material for sheet holder. Polypropylene is the most common plastic material used in automobile industry [3]. Its mechanical properties are described in table 4.2.

Table 4.2 Mechanical properties of Polypropylene material [8, 30].

Mechanical property	Value
Density	0.9 g/cm^3
Poisson ratio	0.45
Young's modulus	0.83 GPa
Tensile strength	35 MPa
Yield Strength	23 MPa

A detailed drawing of sheet holder is shown in figure 4.8. Length, width & thickness dimensions are $560, 50$ & 7.75 mm respectively. Sheet holder has a base sheet of thickness 1 mm . Polycarbonate sheet is fixed in the slot provided at the bottom of sheet holder's base sheet. Width of this slot is 0.75 mm . At the bottom of the slot 1 mm thick support is provided. This support is provided for the easy insertion & fixation of the sheet. Ribs are extruded 5 mm on the top face of the base sheet. Thickness of all ribs is 1 mm . Side protrusions are extruded 2.5 mm from the side walls of the sheet holder. These protrusions are six in number, three on each side wall. These protrusions are provided for holding wheels. The centre to centre distance between two protrusions is 15 mm .

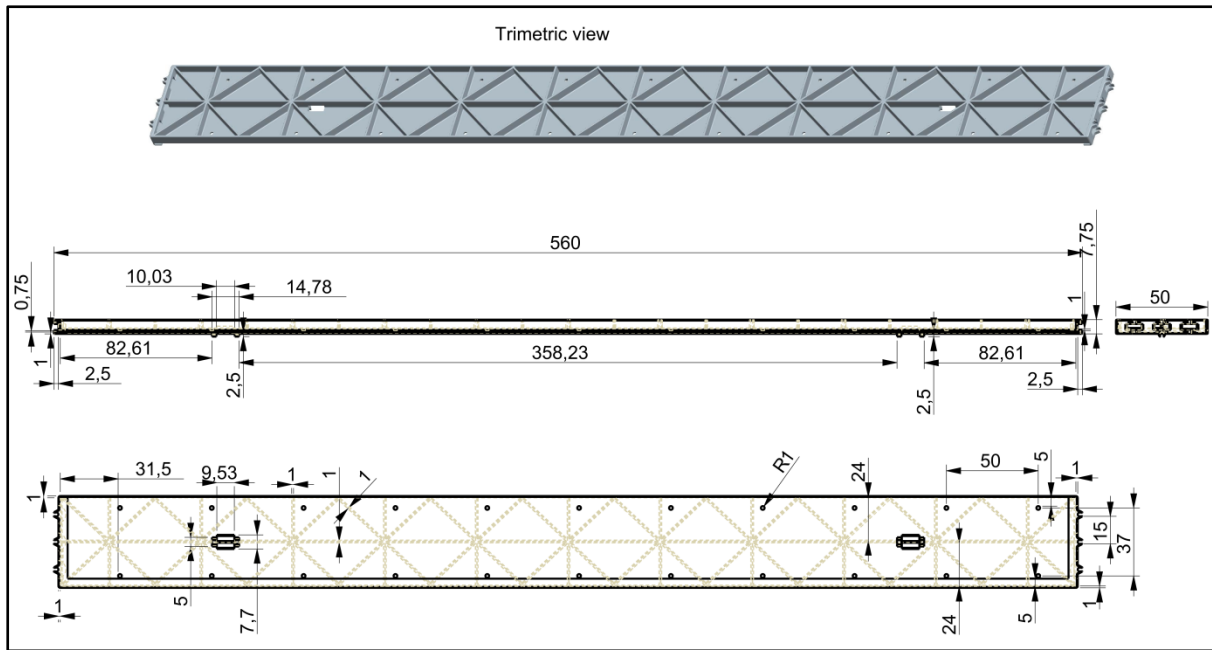


Figure 4.8: Sheet holder drawings

There are two protrusions attached on the bottom face of the base sheet. These protrusions are extruded 2.5 mm from the bottom face of base sheet. These protrusions are provided for holding bottom rollers. These rollers are provided to avoid sagging and lateral movement of the sheet. The design of base sheet is perforated. These holes are rivets holes. The radius of holes is 1 mm.

4.2.1 Protrusion Design

All the side and bottom protrusions have same dimensions. Several iterations have been performed before finalizing the optimized protrusion design. These protrusions are designed for holding side wheels & bottom roller's pins. It is desired that the pin get easily fit in these protrusions. Even with the force exerted by human thumb. The initially designed protrusion drawings are shown in figure 4.9. The radius of the hole is 1 mm. Initially the gap at the opening is kept 1.25 mm. It was assumed that the wheel pin would push fit and this gap would open 0.75 mm further within plastic limits. For this stress analysis has been performed to check, whether the stresses induced in the protrusion part due to applied force, to get the required opening are within permissible limit. Force is applied at the opening faces of the protrusion as shown in figure 4.10.

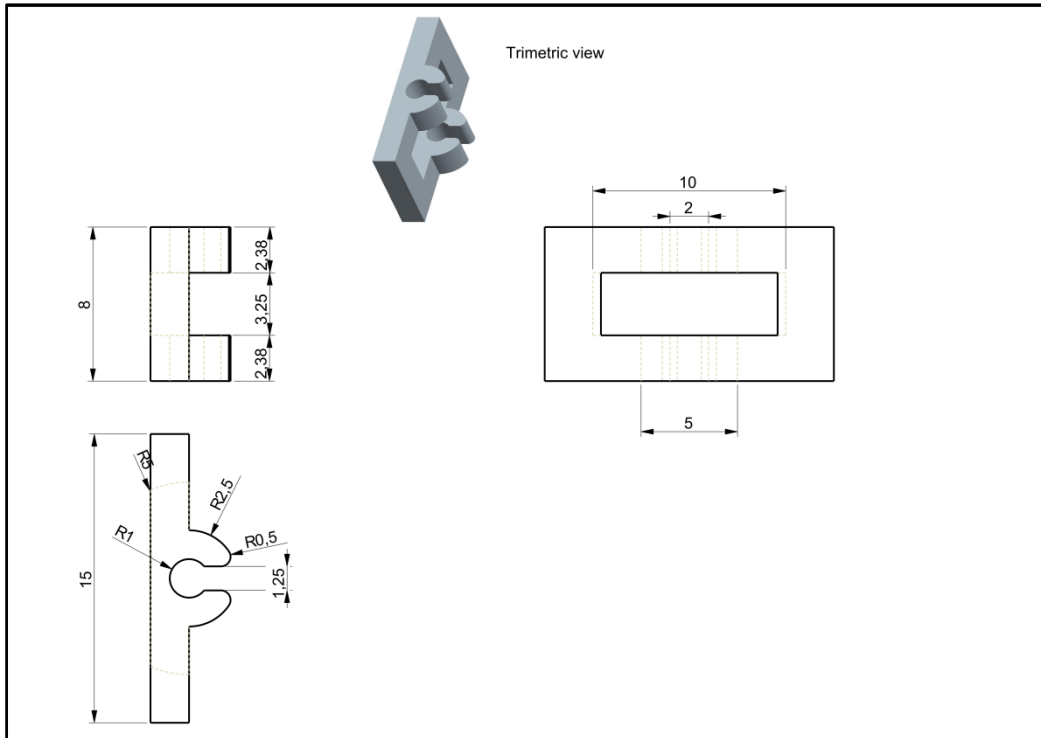


Figure 4.9: Drawings of initially designed protrusions.

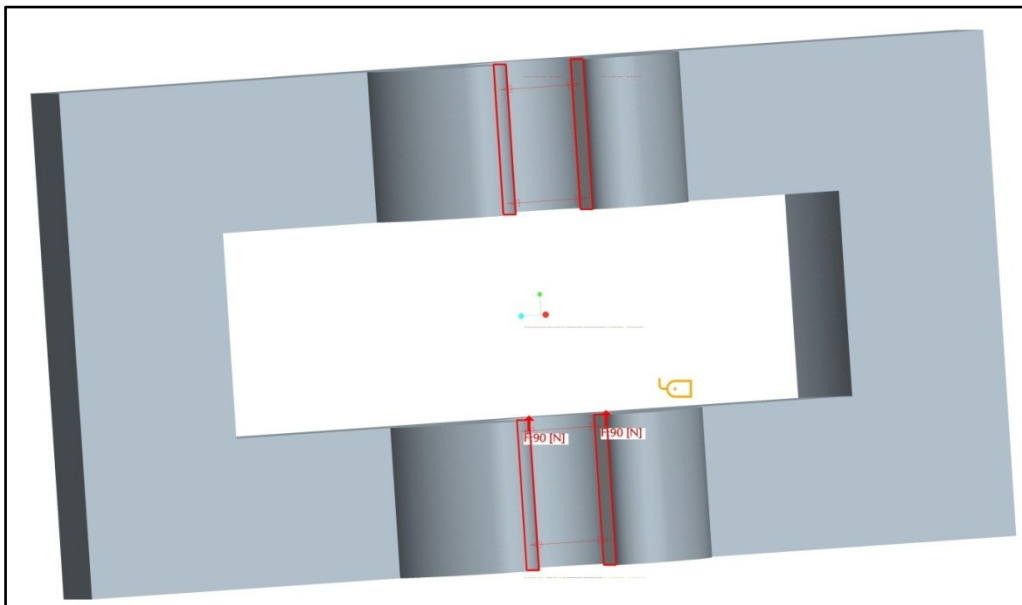


Figure 4.10: Direction of applied force.

Stresses produced and displacement results for of Gap dimension with respect to displacement and stress values achievable between to faces of wheel holder protrusion under 10N force results are shown in figure 4.11.

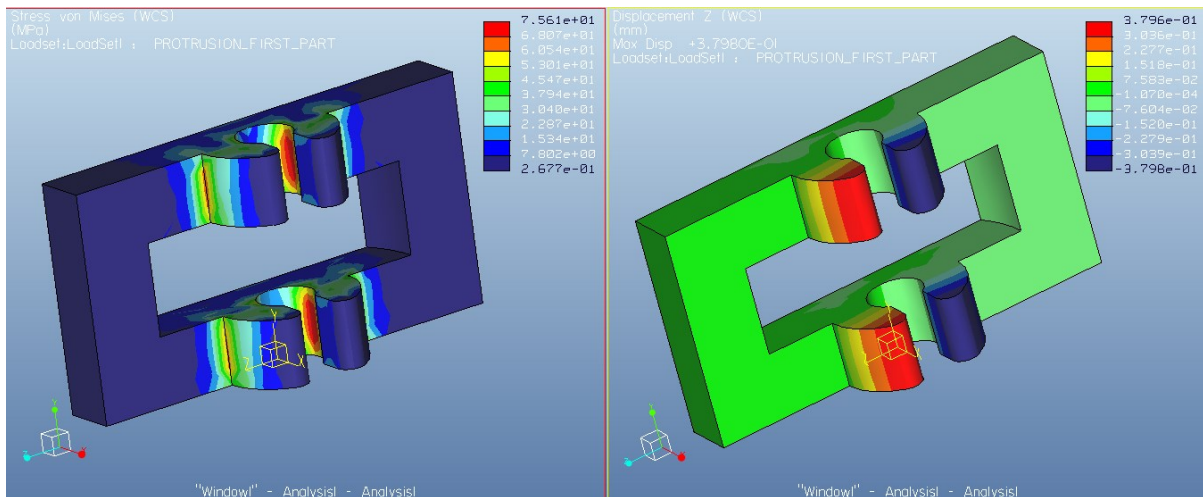


Figure 4.11: Stress and displacement result of initially designed protrusion part under 10N force

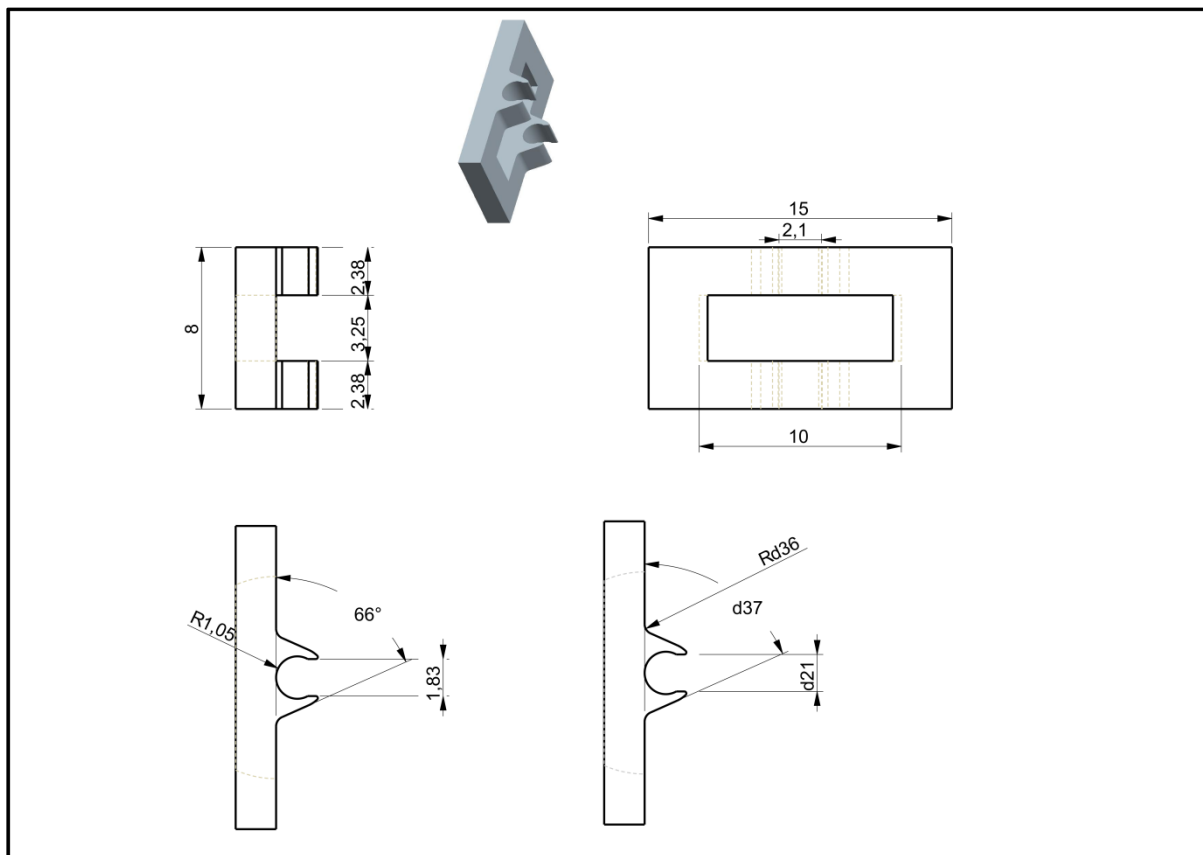


Figure 4.12: Re-designed protrusion part drawings

Initially total 20 N force has been applied 10 N on each face. But at this force the displacement value was very less. Then, the applied force value has been further increased to get the required displacement value. Several iteration has been performed. The value of displacement comes out 0.3798 mm on each side at total applied force of 180 N. But at this much force, the maximum stress produced in the protrusion part comes out 75.61 MPa. Maximum stress value is beyond the permissible limit given in table 4.2.

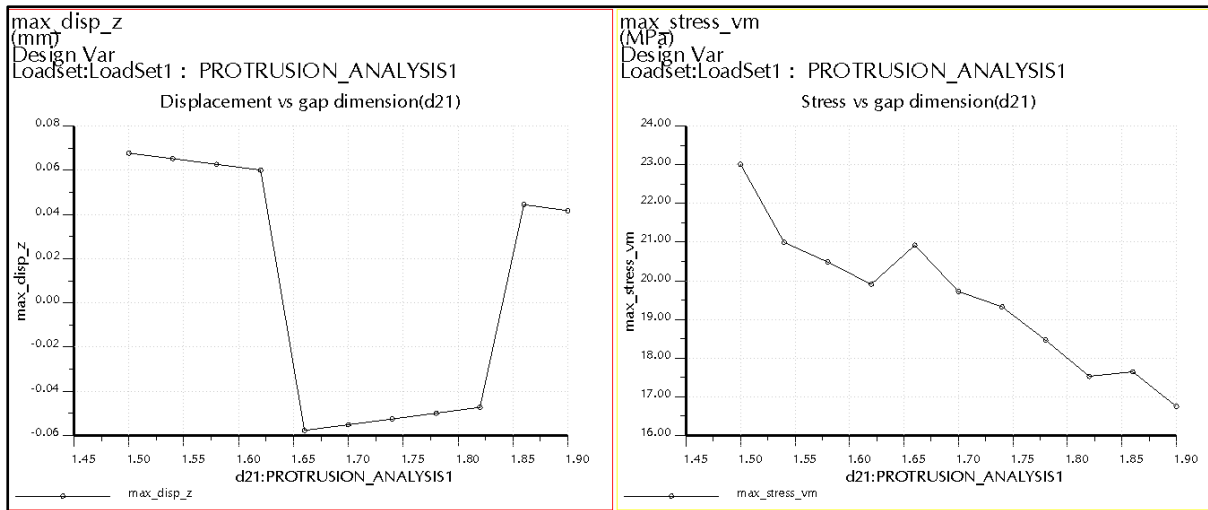


Figure 4.13: Results for sensitivity analysis of Gap dimension (D21) with respect to displacement and stress values achievable between to faces of wheel holder protrusion under 10N force

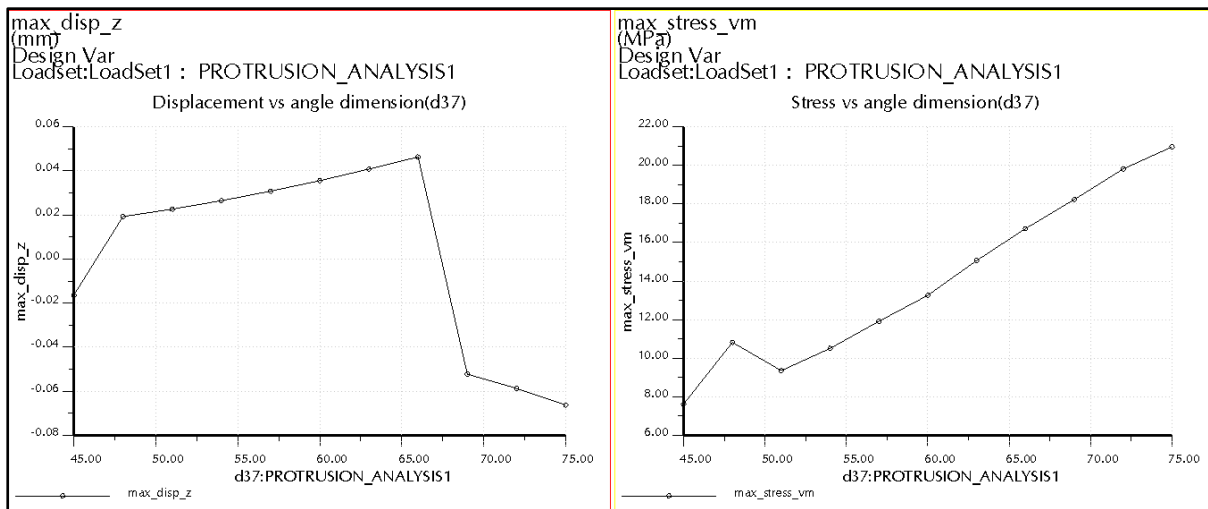


Figure 4.14: Results for sensitivity analysis of Angle dimension (D37) with respect to displacement and stress values achievable between to faces of wheel holder protrusion under 10N force

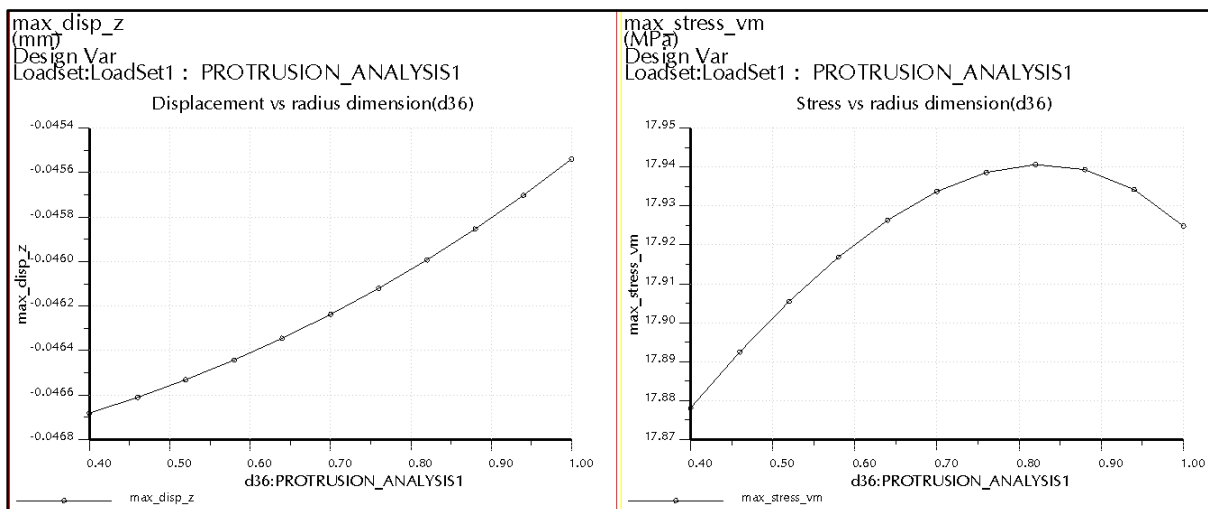


Figure 4.15: Results for sensitivity analysis of radius dimension (D36) with respect to displacement and stress values achievable between to faces of wheel holder protrusion under 10N force

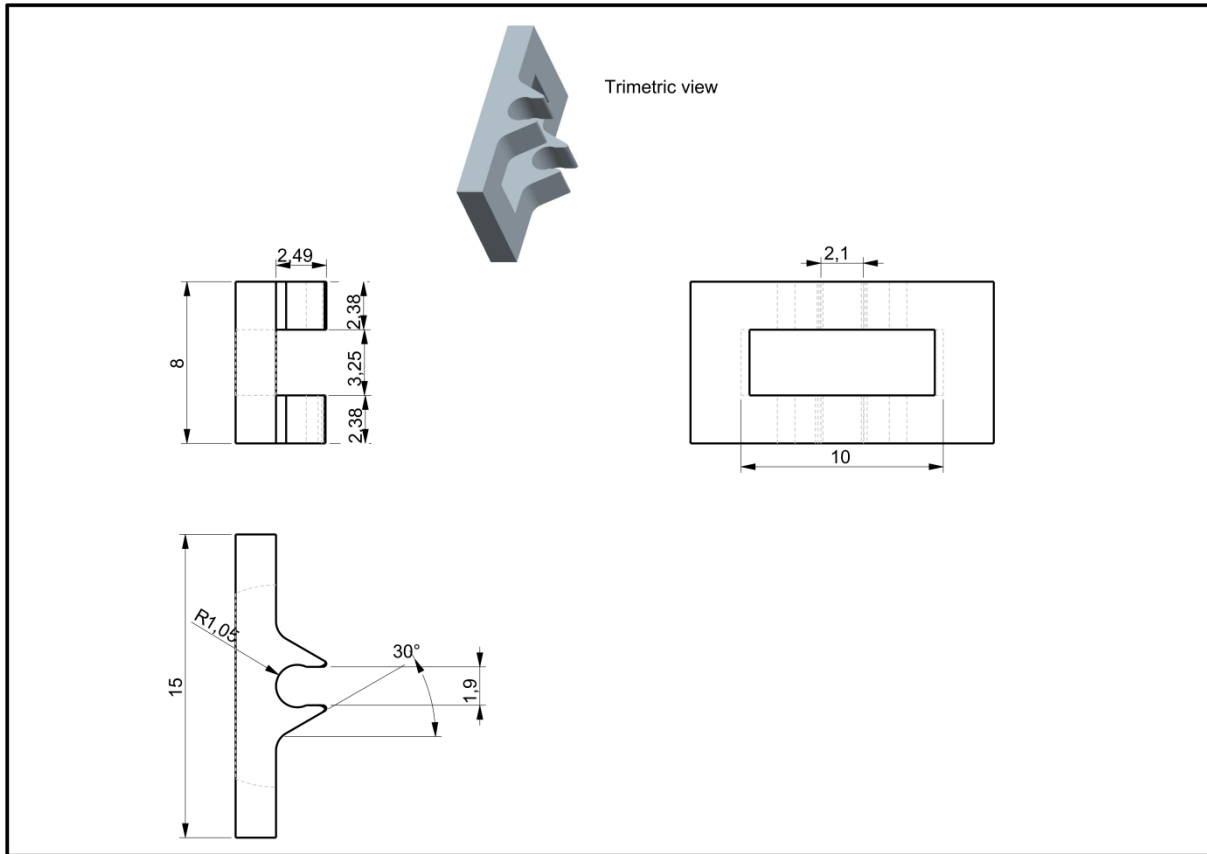


Figure 4.16: Optimized protrusion part drawings

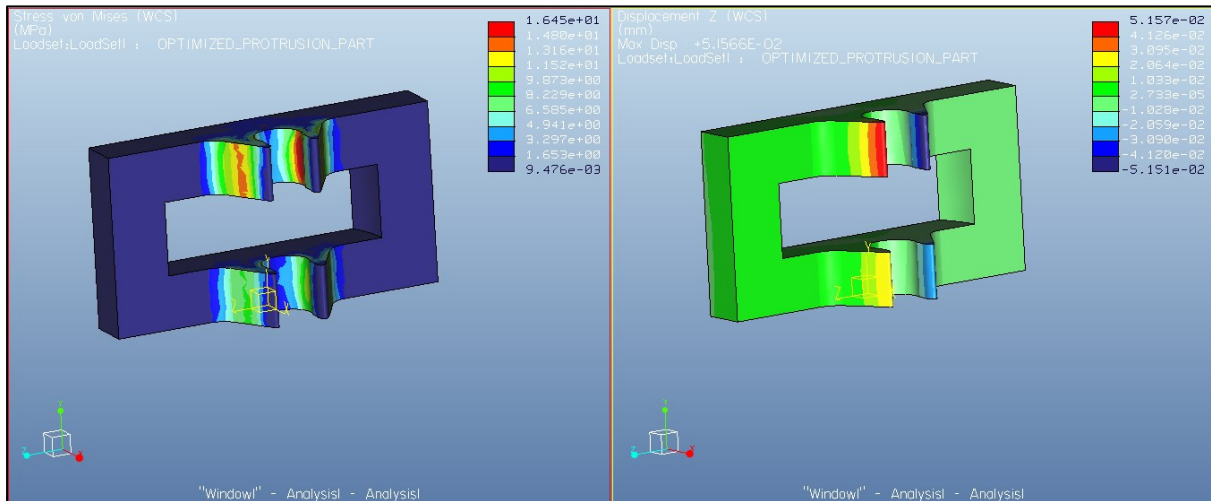


Figure 4.17: Stress and displacement analysis results for the final protrusion model.

The protrusion part is redesigned several times. Sensitivity analysis has been performed on three critical dimensions (d_{21} , d_{36} & d_{37}) shown in figure 4.12. Sensitivity analysis results are shown in figures 4.13 to 4.15. First the force of 10 N has been applied. It can be clearly seen from the figure that, if the value of d_{21} decreases stress and displacement value also decreases. At $d_{21} = 1.83 \text{ mm}$ stress value is within permissible limit. In second graph if the value of d_{37} increases stress and displacement values also increases. At $d_{37} = 66^\circ$ stress

value is within permissible limit. In third graph if the value of $d36$ increases stress and displacement value also increases. In all three analyses stress values are within permissible limits, but the displacement value is less than the desired value. The part is again re- designed several times. The final part drawings are shown in figure 4.16. Stresses produced and displacement value is shown in figure 4.17. It is clearly seen that, in optimized part $d21$ value is 1.90 mm and $d37$ value is 30° . And the radius of the protrusion hole is 1.05 mm . Maximum stress produced is 16.45 MPa , which is within the plastic limit of the part material. The Value of $d21$ is 1.9 mm . Value of displacement is 0.05157 mm

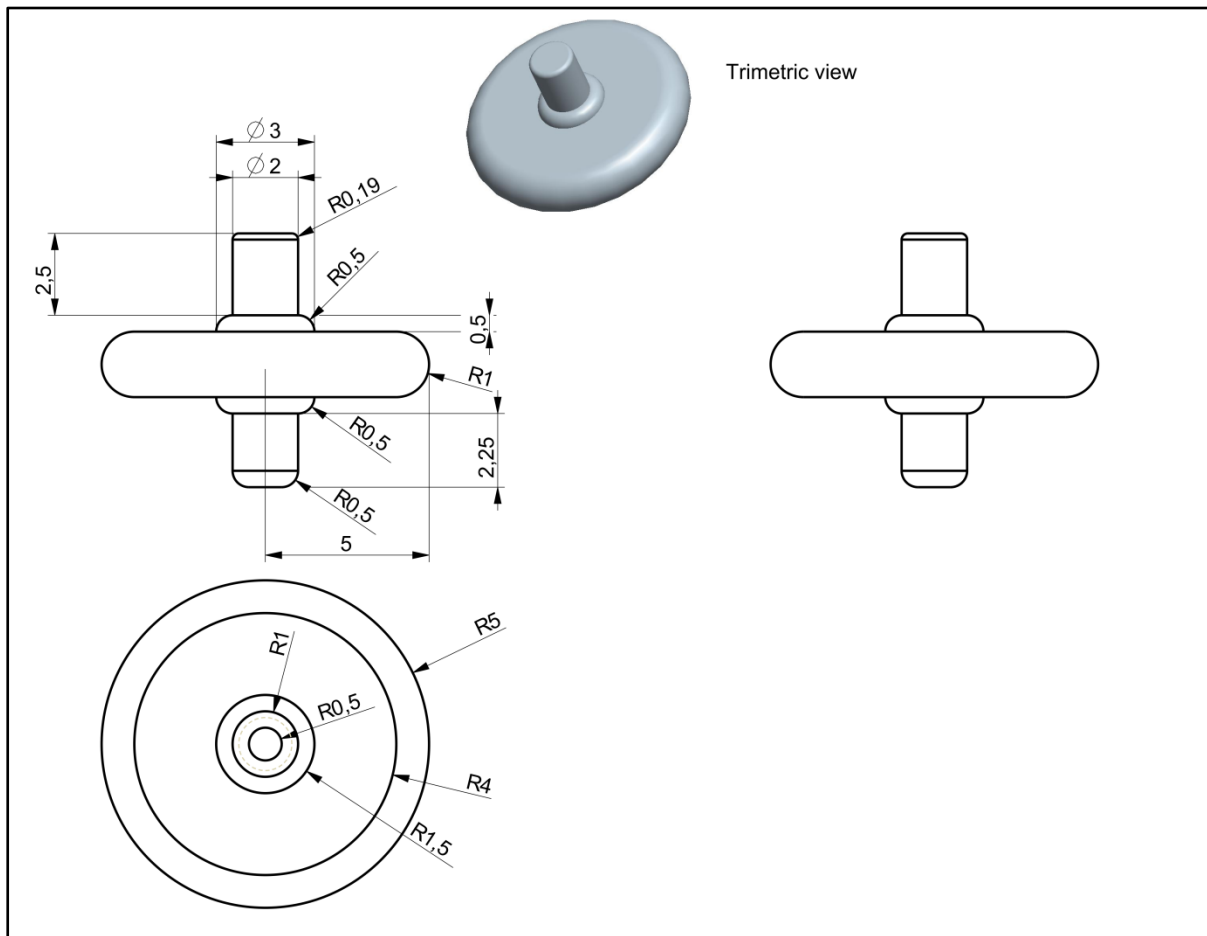


Figure 4.18: Wheel part drawings

4.3 Design of Wheel for Moving the Visor Sheet Sub-Assembly

Wheels are used for smooth rolling friction. These wheels are pushed fit in protrusions mounted on the side walls of the sheet holder. These wheels roll in channels, provided on the side walls of the main cover part. Six wheels are used, three on each side walls of the sheet holder for guiding the sheet holder in side channels. Weight of the sheet holder and anti-glare sheet is supported by these wheels. So the wheel should be made of high strength material.

Selected material for wheel is steel. Mechanical Properties of steel material is given in table 4.3 below. Pro-e elements built in material library have been used.

Table 4.3: Mechanical properties of Steel material

Mechanical property	Value
Density	7.8 g/cm ³
Poisson ratio	0.27
Young's modulus	199.948 GPa
Yield strength	250 MPa

The figure 4.18 shows the isometric view and the drawings for the designed wheel part. Diameter of the wheel axle pin is taken as $\varnothing 2mm$, while the thickness and diameter of the wheel is taken as 2mm and 10mm.

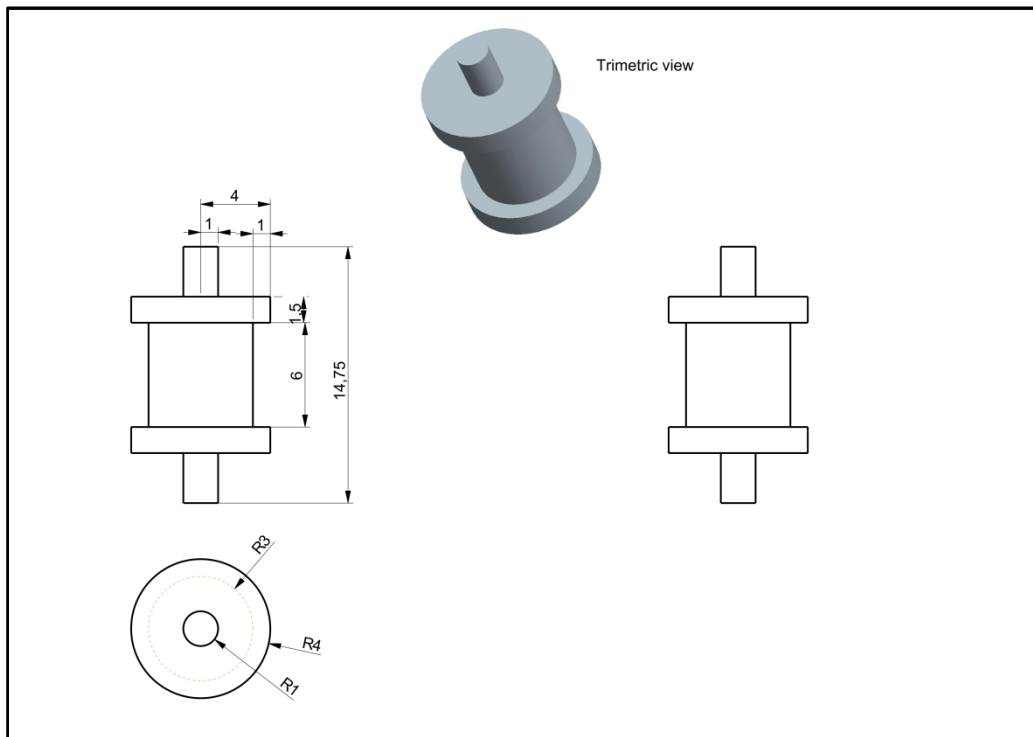


Figure 4.19: Roller drawings

4.4 Design of Rollers for Vertical Support of Visor Sheet Sub-Assembly

Two rollers have been mounted on the bottom face of the base sheet of the sheet holder. These bottom rollers are provided to avoid sagging and lateral movement of the anti-glare sheet. For holding the roller pin same shaped protrusions which are modelled for holding the wheel pin have been mounted on the bottom face of the base sheet of the sheet holder. The design of these protrusions has been discussed earlier. Two protrusions are provided on the main casing. The roller would roll over these protrusions. Weight of the sheet holder and sheet is supported by these rollers. So these rollers are required to be made of high strength

material. Selected material for rollers is steel. Mechanical properties of material are described in table 4.3. Drawing of roller is shown in Figure 4.19. Length and radius of steel shaft is 14.75mm & 1mm respectively. Length and radius of the middle of the roller is 6mm & 3mm respectively. The middle part of the roller will roll over the protrusions provided on the main casing. Radius and thickness of side walls is 4mm & 1.5mm respectively. These side walls are provided so that the roller would move freely.

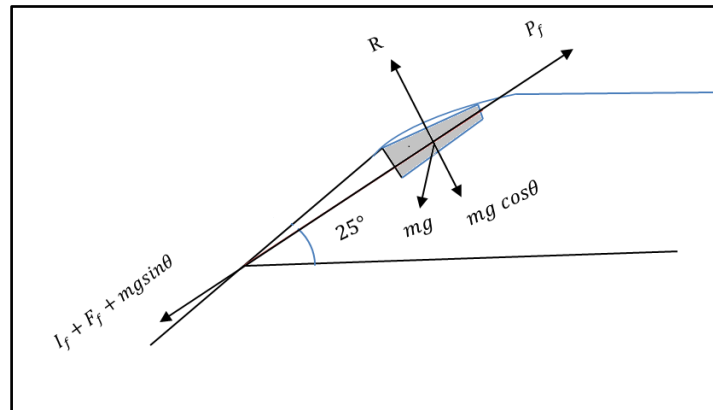


Figure 4.20: Visor inclination angle with horizontal line

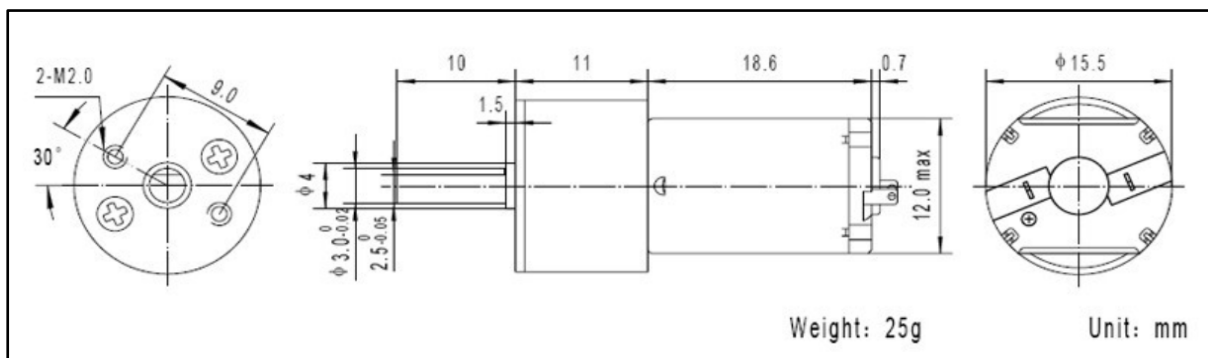


Figure 4.21: Motor drawings [31]

4.5 Motor Selection for Actuation of Visor Sheet Sub-Assembly

Electric actuator is required to drive the sub assembly of sheet and sheet holder, with two free moving steel guide rollers at the bottom with side wheels. In this case positional accuracy is not an important factor, so it is proposed to use simple DC motor for smooth and continuous motion of the movable sub assembly within limits governed by limit switches mounted at the end. Use of DC motor is cost effective, easy to control using potentiometer. No, microprocessor based controller is required as in case of stepper motor. But the selected motor should be able to deliver the required torque with reasonable response time. More over

the selected drive should be such that it can be duly fitted in the available space. Following criteria has been used to select the motor.

1. Torque
2. Space
3. Cost

Motor selection has been done on the basis of calculated torque. Anti-glare sheet is making an angle of 25° with car windshield. Angle value has been calculated from the available car model as shown in figure 4.20. P_f Is the force required to pull up the sheet to visor casing. Mass of the sheet holding part assembly is denoted by symbol m . Mass is divided into two components $mg \cos\theta$ & $mg \sin\theta$. Inertia force is denoted by I_f and R is the normal reaction force. Frictional force is calculated using this formula.

$$F_f = \mu R \quad 4.1$$

Where, μ is the coefficient of friction and R is the normal reaction force. Wheels and roller parts material is steel and channels are made of nylon material. The value of rolling coefficient of friction between steel and nylon is 0.027 [22]. The value of normal reaction can be found from formula given below:

$$R = mg \cos\theta \quad 4.2$$

Mass of the film holding part assembly (Visor Sheet Sub-Assembly) is calculated in Pro-E 5.0 CAD environment which comes out to be 0.20782309 kg . Putting all these values in equation 4.1 will get frictional force.

$$F_f = 0.027 \times 0.20782309 \times 10 \times (\cos 25^\circ) \quad 4.3$$

$$F_f = 0.005085495489 \text{ N} \quad 4.4$$

If the value of $mg \sin\theta$ is more than this calculate force, the part will move downward.

$$0.20782309 \times 10 \times (\sin 25^\circ) = 0.8782983305 \text{ N} \quad 4.5$$

$$mg \sin\theta > F_f \quad 4.6$$

$$I_f = ma \quad 4.7$$

Where, m is the mass and a is the acceleration. Calculated visor speed is 40 mm/s and it is assumed that the motor has a response of 0.1

$$a = 40/0.1 = 400 \text{ mm/s} = 0.4 \text{ m/s} \quad 4.8$$

$$I_f = 0.20782309 \times 0.4 = 0.083129236 \text{ N} \quad 4.9$$

Now, all three $I_f + F_f + mg \sin\theta$ forces will be added up.

$$P_f = I_f + F_f + mg \sin\theta = 1.0123 \text{ N} \quad 4.10$$

$$T_{designed} = P_f \times r \quad 4.11$$

Where, P_f is the pulling force and r is the radius of pulley.

$$T_{designed} = 1.012282521 \times 5 = 5.061412607 \quad 4.12$$

$$T_{motor} = T_{designed} \times 1.5 = 7.59211819 \text{ Nmm} \quad 4.13$$

Motor of 50 *Nmm* torque is available make by Need-For-Power Motor Co., Ltd [23]. Motor drawings are given in figure 4.20.

4.5.1 Finding the Belt Length

Two timing pulleys and a timing belt drive arrangement has been used to actuate the sub assembly of sheet and sheet holder as shown in figure 4.1. One pulley is mounted on the motor shaft and another one is mounted on the pulley mounting. Diameter of both the pulleys is 10 mm. Diameter value has been decided on the basis of the available space for mounting pulleys in main casing. Length of the belt is calculated by the given formula.

$$L = \pi(r_1 + r_2) + 2x + (r_1 - r_2)^2/x \quad 4.14$$

Where, r_1 & r_2 represent the radius of pulleys which are taken as to be equal to 5mm.

x = centre to centre distance between pulleys, calculated distance is 357mm.

Putting these values in equation 4.14, we will get the length of the belt.

$$L = \pi(5 + 5) + 2(360) + (5 - 5)^2/357 \quad 4.14$$

$$L = 751.43 \text{ mm} \quad 4.15$$

4.6 Crash Analysis of Visor Sheet

Crash analyses are performed to measure the safety level of the occupant. Generally crash analyses are performed in cars to check the strength of the car sheet material while collision. In this study Anti-glare sheet Crash analyses have been performed in *Ansys Workbench's Explicit Dynamic module*. This analysis has been performed to analyse the deformation behaviour of sheet, if the sheet strikes with an obstacle while in motion. Calculated visor speed is 40 *mm/s*. At this speed Polycarbonate sheet strikes with an obstacle made of structural steel material. The deformation results are shown in figure 4.22.

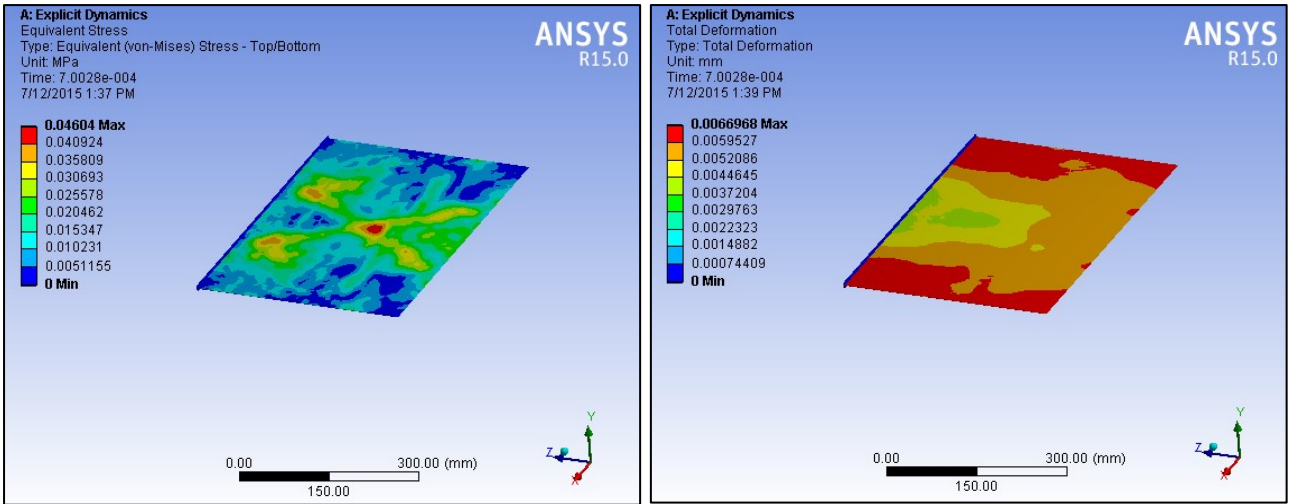


Figure 4.22: Anti-glare film Crash analysis result

The value of maximum stresses is found to be 0.04604 MPa, which is quite small and the value of maximum deformation is also coming in microns the value is 0.0066968 mm. These results show that the selected thickness of the visor sheet is quite safe for the intended application.

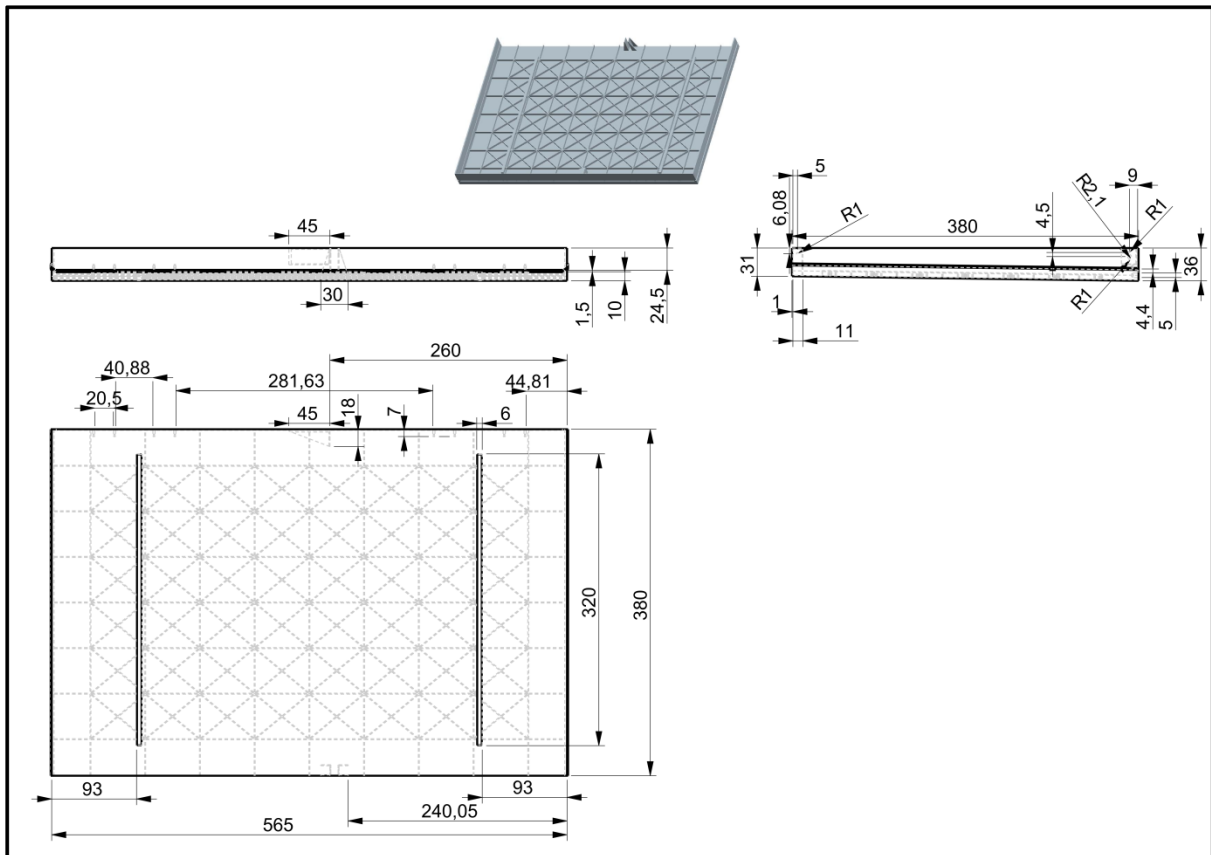


Figure 4.23: Main casing part drawings

4.7 Main Casing of the Visor System

In main casing three side walls are extruded from the base sheet of 1 mm. Wheel channels are provided on the side walls of the main casing. Motor mounting is mounted on the inner face of the front wall. Pulley mounting is mounted on the top face of the base sheet. Four pairs of soft rollers mountings are also mounted on the inner face of the front wall. These rollers are mounted for providing support to sheet part. Anti-glare sheet will move freely in between these rollers. A slot is provided on front wall. Through this slot sheet will move in and out of the casing. Casing part is made up of nylon material. Nylon material is widely used in automobiles because of good mechanical properties, low cost and easy to manufacture property [3]. Mechanical properties of nylon material are given in table 4.4.

Table 4.4: Mechanical properties of nylon material [8]

Mechanical property	Value
Density	1.12 g/cm^3
Poisson ratio	0.39
Young's modulus	3.5 GPa
Tensile strength	66 MPa

Main casing drawings are shown in figure 4.23. Length and width is 380 & 565 mm respectively.

Base sheet thickness is 1 mm. Side wall are extruded on the top face of the base sheet. These two walls are tapered shaped. From front and back the height dimension is 36 & 31 mm respectively. Bottom roller protrusions are extruded on the top face of the base sheet. Length, height and width of bottom roller protrusion are 320, 5 & 6 mm respectively. Anti-glare sheet opening slot width is 1.5 mm. Motor mounting is mounted on the inner face of the front wall. The dimensions are given in figure. Pulley mounting is mounted on the base sheet. Dimensions are shown in figure.

4.8 Analysis of Motor Mounting Support

Tension force P_f , in belt which is used to pull the visor sheet sub-assembly has been computed in section 4.5 in equation 4.10 which comes out to be 1.0123 N. Stress and displacement analysis for motor mounting under belt tension has been performed considering this value of the pulling force acting on the motor shaft. The location of the pulling force has been taken on axis of the motor shaft at the location where the central plane of the pulley intersects the motor axis. Results for this analysis are shown in figure 4.24 below.

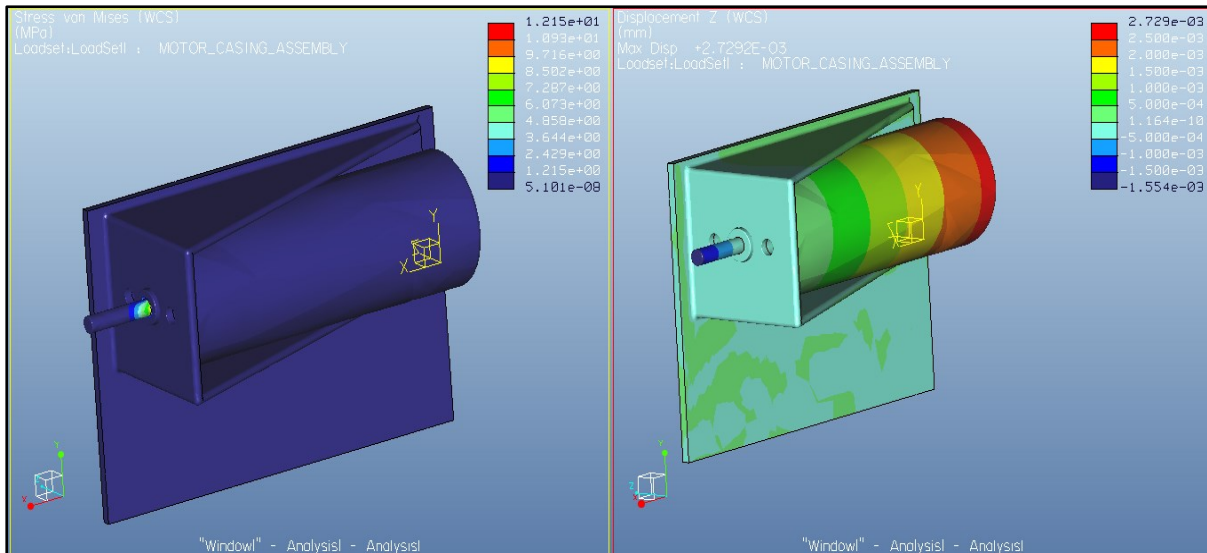


Figure 4.24: Stress and deformation analysis of motor mounting under belt tension (applied force is 2N)

It can be clearly seen that the maximum stress value is coming within permissible limit and deformation is very less. It is also observed that motor mounting is under no stress.

4.9 Design of Visor System Casing Cover

Casing cover for main visor casing is designed with 2mm thick material which covers the main casing of the visor system. It will be used for fixing the visor system inside the car roof insulation. Depending upon the interior roof design of the car cabin this part will have to be redesigned. Thus we have avoided the detailed design of this component. The same material for this component can be used as used for main casing, for which the material properties are shown in table 4.4. Assembled view of visor casing can be shown in figure 4.25.

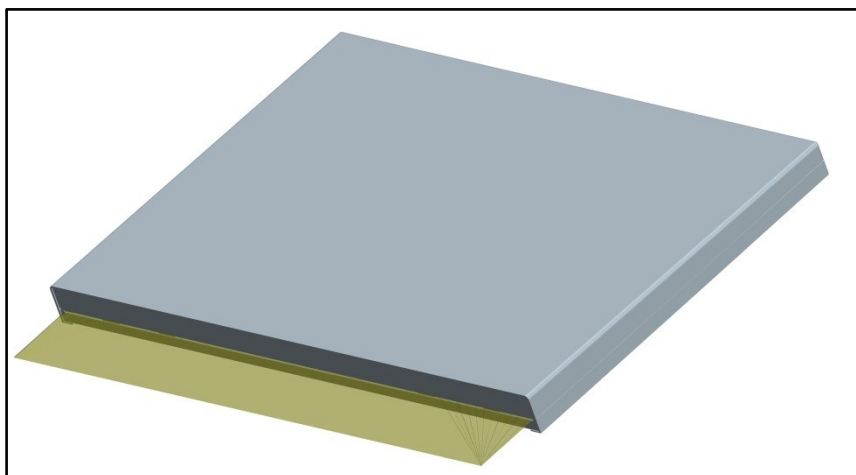


Figure 4.25: Assembled visor system

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

Sun glare while driving could lead to fatal results. Conventional sun visor in passenger cars can only screen out sun glare affect, when sun is high in the sky. Sun changes its position from east to west, and it has been observed that sun glare affect is very dangerous when sun is positioned near to the horizon early in morning and late in evening. At this time, when sun is near to the horizon, conventional sun visor is less effective to eliminate/reduce direct sun glare affect. Many inventions in this area have shown that, it is possible to reduce sun glare affect using sun visor extensions. In this study an effective automotive sun visor has been designed. Modelling/drafting and analysis of key components has been done in Creo elements/Pro 5.0 design software. Key features of designed sun visor system are listed below.

- Visor is designed ergonomically so that large Indian population can avail benefit as the visor system is designed considering the range of driver body dimensions from 95th percentile Indian male body dimensions to 95th percentile Indian female body dimensions.
- Automobile Standards for vehicle cabin design has been followed using the design data available from bench mark data provided by Porsche engineering services [29]. Standardized design procedure has been followed while taking the material properties and dimensions for Visor parts.
- Material selection has been done as per ARAI plastic material selection standards.
- The design of the various parts has been iterated several times to accommodate the range of driver body dimensions and key parameters like horizontal and vertical visibility from the Eyellipse positions has been taken care of as per stipulated SAE and ARAI standards. The final driving dimensions for key components have been chosen from sensitivity analysis done in ProE.
- The FEM analysis of the designed parts has been done in Pro-Mechanica and Ansys. The final analysis results for the key components revealed that the parts are quite safe for the intended application.
- The designed visor system can be fixed inside the roof insulation and it will add more esteemed look to the car cabin and also help in preventing the injuries to the driver caused due to metallic hinge used in case of conventional visor system.

- The designed semi-automatic visor system can be operated using a toggle switch similar to the one used in power windows, thus will add to the convenience to the vehicle driver for adjustment of opening of visor's sun shield.

5.2 Future Scope

In present study an effective passenger car sun visor has been mechanically designed. Future scope of this work is listed below.

- For further improvements this study can be performed to check the feasibility for manufacturing and operations of the visor system.
- In present study as limited to design aspect and less focus as given to explore the possible plastic materials that can be used in various components of the visor system. Future study can be performed to explore the refinement of the proposed design using more superior grade materials for all components.
- The proposed sun visor system can be made automatic using temperature, light and position sensors.
- Sensor based smart visor can be designed for automobiles to use the sun light as source of energy and simultaneously some means can be developed for causing barriers for sun light avoid direct sun light on the human subjects.

REFERENCES

1. Hagita K. and Mori K. 2011, Analysis of the Influence of Sun Glare on Traffic Accidents in Japan, *Journal of the Eastern Asia Society for Transportation Studies*, 9:1775-1785.
2. Mitra Sudeshna. 2014, Sun glare and road safety, an empirical investigation of intersection crashes, *Safety Science*, 70(2014) 246-254.
3. Szeteiova .I.K. 2010, Automobile materials plastics in automotive markets today, Institute of production technologies.
4. Vietro.V.D , Belforte L, Lsmbertini V.G and Fracassi. 2014, Low pressure plasma modified polycarbonate: A transparent, low reflective and scratch resistant material for automobile applications, *Applied Surface Science*, 307(2014) 698-703.
5. Walley S.M, Field J.E, Blair P.W. and Milford A.J. 2004, The effect of temperature on the impact behavior of glass/polycarbonate laminates, *International Journal of Impact Engineering*, 30(2004) 31-53.
6. Noborisaka M, Kodama H, Nagashima S, Shirakura A, Horiuchi T & Suzuki T. 2012, Synthesis of transparent and hard SiOC(-H) thin film on the polycarbonate substrate by PECVD method, *Surface & Coating Technology*, 206 (2012) 2581-2584.
7. Karl Citek. 2014, Anti-reflective coatings reflect ultraviolet radiations, *Optometry* 79, 143-148.
8. Alireza Ashori. 2008, Wood-plastic composite as promising green-composites for automobile industries, *Bio resource Technology*, 99(2008) 4661-4667.
9. Richard E. Stamper & Don L. Dekker. 2000, Utilizing rapid prototyping to enhance undergraduate engineering education, *IEEE Frontiers in education conference*, 0-7803-6424-4.
10. Zhao H, Zhu H.Y, Zhou Y.L & Wang Q.W. 2011, Research of wood plastic composites application based on fused deposition modeling technology, *International conference on electronic & mechanical engineering and information technology*, 978-1-61284-088-8/11.
11. Saman A.M, Abdullah A.H and Mohd N.M.A. 2009, Computer simulation opportunity in plastic injection mold development for automotive part, *International conference on computer technology and development*, 978-0-7695-3892-1/09.
12. Anderson J C. 2002, Teaching the manufacturing design cycle in a project course, *IEEE Frontiers in Education conference*, 0-7803-7444-4/02.

13. Guijian H, Xuemei L, Xiaoyu W and Jibin L. 2009, Optimized design of injection mould for mobile phone front shell based on CAE technology, International joint conference on artificial intelligence, 978-0-7695-3615-6/09.
14. Du Q.G, Alagappan G, Dai H, Demir H.V, Yu H.Y, Sun X.W and Kam C.H. 2012, UV-blocking ZnO nanostructure anti-reflective coatings, Optics Communications, 285(2012)3338-3241.
15. Sain M, Park S.H, Suhara F and Law. S. 2004, Flame retardant and mechanical properties of natural fiber-PP composites containing magnesium hydroxide, Polymer degradation and stability, 83(2004) 363-367.
16. Motor vehicle dimensions, SAE standard J1100, 2001.
17. Devices for use in defining and measuring vehicle seating accommodation, SAE standard J826, 1995.
18. Motor vehicle driver's eye locations, SAE standard J941, 1992.
19. Field of vision of motor vehicle drivers for M1 category, Automotive industry standard AIS-021, 2011.
20. Automobile vehicles-safety glazing materials for motor vehicle- methods of test and requirement, Automotive industry standard AIS-118, 2012.
21. Standard test method for tensile properties of plastics, ASTM standard D638.
22. Elahi A.H.M.F and Rahman M.S. 2014, Intelligent windshield for automotive vehicles, International conference on computer and information technology, 978-1-4799-6288-4/14.
23. E.Q. Nygaard, "Sun visor for vehicles," U.S Patent 2733763 A, Feb 7, 1956.
24. Williams Albert, "Adjustable glare shield and mirror attachments for automobile visors," U.S Patent 2894576 A, July 14, 1959.
25. J.D.Acuff, "Vehicle sun blindness eliminator," U.S Patent 4003597 A, Jan 18, 1977.
26. Anatoli Vistitsky, "Vehicle sun visor," U.S Patent 4090732 A, May 23, 1978.
27. www.lawresources.org
28. <http://iitg.vlab.co.in> (last access 6/17/2015, time 11:29 AM).
29. www.worldautosteel.org.
30. <http://www.vinidex.com.au/technical/material-properties/polypropylene-properties/> (last access 7/13/2015, time 8:56 AM).
31. <http://www.nfpmotor.com/NFP-GMS16-030.html> (last access 5/13/2015, time 8:00 PM).
32. [http://mscrecon.com/photo12/14/2014\(2.30\)](http://mscrecon.com/photo12/14/2014(2.30))
33. <http://www.epa.gov/sunwise/doc/uvradiation.html> 12/14/2014(2 pm)

34. <https://grabcad.com> 12/14/2014(5.55 pm)
35. <http://www.aliexpress.com> 12/14/2014(7 pm)
36. <http://www.goodfellow.com/E/Polycarbonate.html>. (5/14/2015)
37. <http://www.theplasticshop.co.uk/polycarbonate-sheet-index.html> (5/14/2015)
38. <http://www.ebay.com/bhp/sun-visor-extension> (5/14/2015)