Functional Enhancement Of Indian Cars Using Lambo doors

A Project Report

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report entitled **"Functional Enhancement of Indian Cars using Lambo doors"** is the bonafide work of

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ABSTRACT

The project 'FUNCTIONAL ENHANCEMENT OF INDIAN CARS USING LAMBO DOORS' deals with innovative design and fabrication of a car door hinge to make it look like and function like a scissor door. By altering the door of Indian cars in this way we intend to reduce the parking space clearance needed for opening the door. Vertical doors or scissor doors were invented by automobile company Lamborghini Automobili, and so the doors are also called lambo doors. The hinge design for this model is a new one and is correctly suited for Indian cars. Using this hinge these doors can be fitted in Indian cars with minimum alteration.

The present invention provides a door hinge mechanism imparting motion to the door in two directions as it opens or closes. In addition, the present mechanism provides for a motion in two different directions at two different portions of the door's motion cycle. The present invention provides a hinge which allows the door of the vehicle to move outwards in a substantially horizontal plane for a predetermined are, then move vertically upwards thereafter, again for a predetermined arc. By this means, the vehicle frame need not be specially adapted to a door having vertical motion. At the same time, the limited horizontal motion allows a great degree of mitigation of the problems associated with horizontal-only door arcs. Thereafter, the vertical motion is unimpeded by the vehicle frame (being already somewhat distanced from the vehicle) and so a substantial vertical arc upwards may be completed, allowing the user easy entry and exit from the vehicle.

ACKNOWLEDGEMENT

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We are also thankful to all faculty members of the department, especially **Mr. C. Velmurugan,** for the valuable guidance, support and encouragement we were bestowed with during the course of our project work.

We would be failing in our duty, if we do not thank **Mr.Mani** mechanic who took pains to guide us in this endeavor. Our sincere thanks to him without whose worthy suggestions, morale support and above all his valuable guidance, this project would not have seen the light of the day.

Finally, we thank our parents and friends for always being there for us in times of need.

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INTRODUCTION

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INTRODUCTION

1.1 NEED FOR THE PROJECT:

Conventional door hinges on automobiles have a number of problems. As is well known, such conventional systems hinge the door at the front of the edge and swing the door outwards through a horizontal arc which brings the rear edge of the door quite distant from the vehicle body. A spring action which assists in the opening of the door attempts to push the door open to substantially the full distance it is capable of opening. Opening the door in this fashion results in either the door's rear edge hitting whatever is adjacent to the vehicle or else requires the user to "fight" the door to get out of the vehicle. Since vehicles quite often end up parked next to another vehicle allowing the door to swing out and impact the object next to the vehicle is distinctly undesirable.

Even when the user is not forced to limit the door's motion to a safe degree (for example, when the vehicle is parallel parked or parked next to an empty parking spot), the door itself is usually partially in the way of the user. Typically, the door opens somewhat less than 90 degrees and has a substantial width and a fair number of projections such as interior door handle, knobs, window controls, etc. The result is that around one half of the available arc beside the vehicle is covered by the door, making entry and egress a bit more difficult. Occasionally, a user may be blocked from even reaching the vehicle's entryway by the body of the door, for example, when the door is already open and the user approaches the vehicle from the front. Either the door must be partially or wholly closed to allow the user to squeeze past, and then reopened to allow entry, or the user must walk around the vehicle the other direction.

Given the omnipresence of traffic, such diversions from simple entry are dangerous to users, and when vehicles are parked parallel, a projecting door on the driver's side of the vehicle becomes an obstacle and danger to traffic. The projecting door itself is in danger of being struck and damaged by passing vehicles.

One possible solution to the horizontally hinged door is the vertically hinged door. Certain expensive types of automobiles have frames custom designed to support vertically hinged doors. Such doors are hinged to swing straight upwards at opening, in an arc in one dimension. However, it is normally necessary to implement such doors at the time the vehicle frame is designed, so as to allow for a frame which does not impede the top of door when it moves vertically.

1.2 IMPORTANCE:

According to 'The Statistical Society of India' the number of automobiles in India is expected to increase threefold by 2015. The increase in number of automobiles on Indian roads does not comply with the amount of road space available let alone the amount of urban landscape which also increases progressively. One of the problems that will arise is the lack of sufficient parking spaces. Unless addressed at the outset there is a possibility of this problem becoming acute over time.

Currently most upscale buildings have one or two floors dedicated for the purpose of parking. Some others have separate buildings for parking. Even with these facilities, the sight of cars occupying half the road obstructing traffic in busy roads is common. As an effort to address this issue and also to offer fringe benefits that may motivate the users to accept the product, the following project is undertaken.

1.3 IDEA PROPOSED:

The problem is indirectly addressed by attempting to reduce the space a vehicle would occupy in a particular space. One observes that other than the space occupied by the vehicle's body itself, some amount of clearance is being left for the vehicle's door to operate. The idea proposed is to alter the door mechanism of Indian vehicles into one that would somehow open occupying lesser parking space. Instances of accidents by opening the door wide will also be reduced. Additionally it has become a trend in western countries to fit this kind of doors on their vehicles as an aesthetic enhancement.

CHAPTER 2

PROBLEM EXPLANATION

CHAPTER 2
PROBLEM EXPLANATION

2.1 THE CONDITION IN INDIA

In India, there has been a 200-fold increase in vehicle population between 1951 and 2002. India's transport policy over the past half-century is illustrative of its bias towards expanding infrastructure at the cost of equality of access. Between 1951 and 2002, there was a nearly nine-fold increase in road length and a nearly 200-fold increase in vehicle population. Much of this infrastructure was vital to connect cities and towns around the country. But a considerable degree of road expansion took place within urban areas, which is reflected in the explosive growth of two-wheelers, now comprising 70% of all vehicles.

In a country with a limited supply of land, parking is a trade off to carefully consider. Traffic will continue to worsen and one will never shift the balance in favor of ways of getting around that are more effective in moving people. Garage doors create large voids in the life of the street and detract from the vitality and character of commercial streets. Turning cars can pose a serious threat to passers-by.

Current parking planning practices are inefficient and often ineffective at solving parking problems. Minimum parking requirements tend to be excessive because they are generally based on demand surveys performed in automobile-dependent locations, and so require more parking than needed in areas with good travel options, accessible land use, or transportation and parking management programs. Yet this overabundance of supply does not eliminate parking problems because spaces are often unavailable for priority uses or are difficult to access.

TABLE 2.1: GROWTH OF POPULATION AND VEHICLES IN METROPOLITAN CITIES.

Major Cites	Population		Annual Growth Rate	Vehicle Population		Annual Growth Rate
	1991	2001	(1991-2001)	1991	2001	(1991-2001)
Mumbai	12,571,720	16,368,084	2.67	629,000	1,069,499	5.45
Kolkata	10,916,272	13,216,546	1.93	475,000	664,046	3.41
Delhi	8,375,188	12,791,458	4.33	1,813,000	3,876,407	7.90
Chennai	5,361,468	6,424,624	1.83	544,000	1,355,550	9.56
Hyderabad	4,280,261	5,533,640	2.60	443,000	950,624	7.93
Bangalore	4,086,548	5,686,844	3.36	577,000	1,680,278	11.28
Ahmedabad	3,297,655	4,519,278	3.20	374,000	899,346	9.17
Pune	2,485,014	3,755,252	4.22	280,000	658,313	8.92
Surat	1,517,076	2,811,466	6.36	197,000	575,373	11.31
Kanpur	2,111,284	2,690,486	2.45	169,000	384,955	8.58
Jaipur	1,514,425	2,324,319	4.38	266,000	693,336	10.05
Lucknow	1,642,134	2,266,933	3.28	216,000	555,773	9.91
Nagpur	1,661,409	2,122,965	2.48	167,000	458,961	10.64
Bhopal	1,063,662	1,454,830	3.18	130,000	333,482	9.88
Coimbatore	1,135,549	1,446,034	2.45	66,000	448,327	21.12
Ludhiana	1,012,062	1,395,053	3.26	202,000	645,686	12.32
Kochi	1,139,543	1,355,406	1.75	29,000	226,185	22.80
Varanasi	1,026,467	1,211,749	1.67	112,000	338,715	11.70

Source: Transportation in the 21st Century by Ranjan K Bose, The New Energy Economy, Edited by G M Pillai, World Institute of Sustainable Energy

2.6 A POSSIBLE REMEDY:

A survey by Business Today says that nearly 38% of all the cars in Indian roads are driven by people in the age group of 18 to 28. The survey also states that nearly 60% of people visiting urban hotspots, which includes the metros and few second tier cities like Pune, Chandigarh, and Bangalore, belong to this age group. The same age group is known to be rebellious at the face of order. So they need to be communicated to in their own channels. Coming up with an innovation, that would solve the crisis as well as appeal to the people though possible, will require more time and effort. The remedy may lie in simpler notions like the idea proposed in this project.

With this project the issue is addressed indirectly. With the growing economy, the buying power of Indian youth has increased three folds in the last eight years. There is also a marked increase in the number of global automobile companies that have started their plants in India. Most of these companies like BMW, Lamborghini and Porsche offer cars and SUVs that are known for their looks as much as their performance. But the pricing of these cars is still lingers in lakhs. This price range is still expensive for the Indians. Consequentially the market for altered or kitted cars, to lend a term from the automobile parlance, has shot up phenomenally. The influence of developed countries is also a reason for this craze. With the clothes, and petrol the temptation of modifying cars as well seems to have been imported as well. It is this growing interest that is intended to cash in to address the issue.

Our project is a popular kit in the car modifying industry. But few of the processes followed by the western countries will not suit the Indian market. The design proposed is a perfect balance of functionality and aesthetics. The idea of making one's car attractive appeals to the age group, identified as being mainly responsible for the shortage.

But before finalizing on scissor model, a general overview of the types of car doors available was made. Then the pros and cons of each door were investigated and finally scissor doors or lambo doors were found to be the right choice.

CHAPTER 3
LITERATURE SURVEY

CHAPTER 3
LITERATURE SURVEY

3.1 TYPES OF DOORS

The project is actually carried over on commercial automobiles, in other words cars. Car doors in western countries are of many types which will be discussed shortly. The reason for the diverse designs in doors is mainly function driven. In India however the doors are not given as much thought as the other parts such as performance, efficiency, and looks. The doors usually found in the automobiles globally are described below.

3.1.1. OEM or Regular:

OEM stands for Original Equipment Manufacturer. This is the kind of door found in most of the automobiles around the world including India. The door is hinged in the front on the body of the car. It swings outwards on the other end. The door was so designed because it is the most practical way of getting inside the car. There are usually two hinges in this type of doors. As is obvious, this is the door we intend to replace. But one must consider the advantages of this door that our replacement must compensate reasonably like its sturdiness as it is supported by two mild steel hinges.

FIG 3.1 AN 'OEM' DOOR IN OPENED POSITION

3.1.2. Scissor Doors:

Scissor or jack knife doors were made famous by the automobile major *Lamborghini Automobili* when they first installed it in their car Countach. The car had an unusually large wheelbase for its time. So making the door swing upwards vertically eliminated the need for door clearance. This allowed the car to be parked in the usual parking space of other cars. These doors have a hinge and a suspension system, mostly hydraulics to lift the door. The Lambo or scissor door was designed for a similar parking space deficiency problem. But one must consider the complications of its design. In all the cars it were designed citing aerodynamics as a reason, the A- pillar was mostly inclined from the vertical. This facilitated the door to be lifted vertically without any obstructions whatsoever. In Indian cars however the door might have to swing out a little before moving upwards. But it is the only one with minimum parking space requirement.

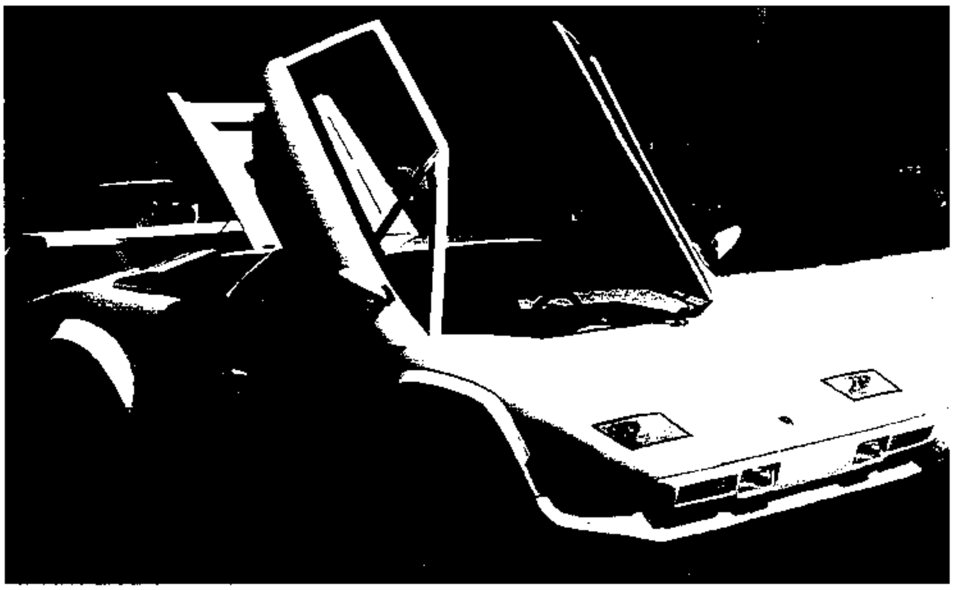


FIG 3.2 A SCISSOR DOOR IN OPENED POSITION

3.1.3. Gullwing Doors:

Gullwing doors are usually confused with Lambo doors by many. The name gullwing comes from the profile of the doors open when looking straight at the car. They rise up as if a seagull in mid flight, about to swing its wings down. The pivot point for these doors is above the passenger compartment, where the roof is. So the roof needs to be sturdily supported because the weight of the door will be placed squarely on the top. The gull wing setup is actually pretty common on Indian vehicles but not for the passenger compartment. SUV's use this setup for their hatchbacks. The door pivots on the roof, opens straight up, out of the way. The door operates on two suspensions mounted on either side of the hinge in the passenger doors, whereas in hatchbacks the hinge and suspensions are incorporated together. Gullwing doors have a huge disadvantage which forms the main criteria for our project. These doors occupy more space than the usual OEM doors. This eliminates this door design from the competition completely. Although designing the hinge system above the passenger compartment is a complicated task by itself. Most Indian cars are not structurally sound enough to support these kinds of doors.

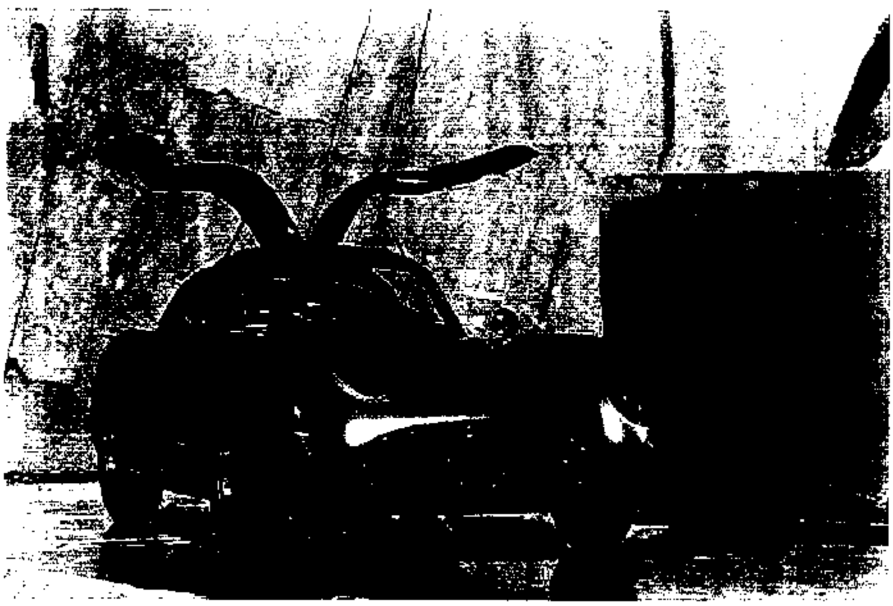


FIG 3.3 A GULLWING DOOR IN OPENED POSITION.

3.1.4. Butterfly Doors:

Butterfly wings are close to scissor doors in that there pivot points are very close, and the doors end up in the same area. The difference is that with butterfly doors the pivot is usually on the a-pillar so that the doors turn towards the front, exposing more of the side of the door towards the front. The profile of a scissor door would be much less from a front angle a butterfly lets you see the side of the door as it pivots sideways and turns up. The butterfly door too satisfies the first factor in our list of requirements. They doors require as little space as the scissor doors discussed above. It also has the advantage of being aesthetically very pleasing. But the drawback in designing this door is its complication. The doors of most Indian cars weigh between 20 and 30 kgs. Supporting them in a single pivot in a way that would allow the door to be turned would require precision engineering and tougher materials than our usual door joints.

FIG 3.4 BUTTERFLY DOORS IN OPEN POSITION.

3.1.5. Suicide Doors:

Suicide doors have their pivot on the exact opposite side of "regular/OEM" doors, so they open up "backwards". The most common place this door is installed is on newer trucks with extended cabs. Truck companies realized that they could have a bigger opening if they put the hinge on the other side, and now bigger people can squeeze into those little compartments behind the front seats. The door is termed 'suicide door' because while driving to avoid some accident one decides to roll out, the door will smack into the person, injuring him. In OEM doors however this is quite unlikely. Technically suicide doors are the same as OEM doors and occupy as much space. The doors offer the only advantage it was designed for in the first place. It leaves a larger doorway than the other models and the complications and advantages are simple.

FIG 3.5 OEM DOOR IN THE FRONT AND SUICIDE DOOR IN THE BACK.

3.1.6. Sliding Doors:

These doors are usually seen in minivans. The door's hinge slides along the body of the van until the full door clears the opening. The door is also used in helicopters of small size, like the Huey 112. Sliding doors are seen in many minivans and even some of the heavy duty vehicles like buses in India. They are the ones that require little or no parking space clearance at all. The door simply offsets from its plane and moves to a plane parallel to the previous one. Though this satisfies the main criteria of our project, it fails for the following reasons. If the door is installed in the front doors for example in a sedan, it prevents opening the rear door. Also using this design would mean installing a slider mechanism along the entire length of the car's body. So for the above reasons this door too is eliminated.

FIG.3.6 A SLIDING DOOR HELD IN A OPEN POSITION

Considering the options listed above one comes to the conclusion that scissor doors are the right choice. The Lambo doors offer the advantage of decreased parking space, and aesthetically appealing looks. The design of this door would mean designing a hinge mechanism that would allow 2 degrees of freedom instead of one and a control system to operate the door. But first one needs to understand the technology and history behind Lambo doors.

3.3 LAMBO DOORS, THE CONCEPT:

Scissor doors, also called Jackknife doors or Lambo doors, are automobile doors that rotate up and forward on a hinge near the front of the door.

This form of door was first introduced in the Alfa Romeo Carabo concept car, designed by Marcello Gandini. Gandini used the same doors in the Lamborghini Countach whose wide chassis mandated this unusual door configuration. The car's unusual length demanded the door to be designed this way. The design of the car made it easy for the door to clear the A-pillar by simply swinging upwards.

The Lamborghini had a very wide base, and a traditional door design would not allow for easy entering and exiting, especially if parked next to anything. They devised a door hinge system that lifts the doors vertically and only slightly out ward, clearing the door of the opening, and also allowing the wide body car to still fit in traditional spaces. The design was carried forward to the Countach's successor, the Lamborghini Diablo. The only current Lamborghini in production which uses this design is the Murciélago.

This design combines some of the advantages of a conventional door and the traditional gullwing door. The door can open upward rather than outward, which is important in widecars. The hinge is in a similar location as a conventional door, so a convertible version of the car is not prevented by the door design.

Although the scissor doors are quite famous, few cars come fitted with these doors. The supercars that come with these doors owing to their aerodynamic design have an inclined A-pillar. This enables the door to be lifted vertically without any of the car parts obstructing its motion.

The aesthetic appeal of the door has enabled many companies like Ford, Daimler Chrysler and BMW have introduced this door in their concept cars. It is a catching trend in western countries to alter their cars with doors of this type. But the mechanism is impractical in our project for the reasons that we will investigate in further chapters.

Catching up with this trend would mean many people would install these kinds of doors in their cars for its aesthetic appeal if not the parking space advantage which is intended to advocate. There are roughly 50 car tuning and performance upgrading workshops in India alone. Yet few of the well known mechanics like Dilip Chabbria have ever tried this design in Indian cars. And the few times it has been tried it has worked wonders.

The success of the previous practices where lambo door was installed has emphasized the success of the design aesthetically, if not functionally.

FIGURE.3.7 A PICTURE OF LAMBORGHINI MURCEILEGO.

3.4 LAMBO DOOR CONVERSIONS

The previous attempts made at creating this sort of doors were successful at the cost of being expensive and modifying the car body frame meddling with the structural stability of the car. It was already mentioned that many performance tuners around the world set up lambo doors in otherwise dull cars for the sole purpose of making it appealing. This is also followed by renowned automobile companies like Daimler Chrysler, Ford and Nissan in their concept cars. But the concept cars, like the original supercar that sported this door, have an inclined or no A- pillar at all. So the study of the working mechanism of aftermarket Lambo doors was undertaken. These doors like our Indian cars have an upright A-pillar blocking the uplifting of the door. So the doors are usually allowed to swing out to a particular angle and then swivel upwards using hydraulic shocks.

Given below is one of the popular designs which are followed by companies like 'Vertical Doors. Inc', 'Wing Doors' and 'Metal King. Inc'. The door completely moves away from the car and then swivels above vertically. The door is supported by two hydraulic shocks. The hinge mechanism is shown below.

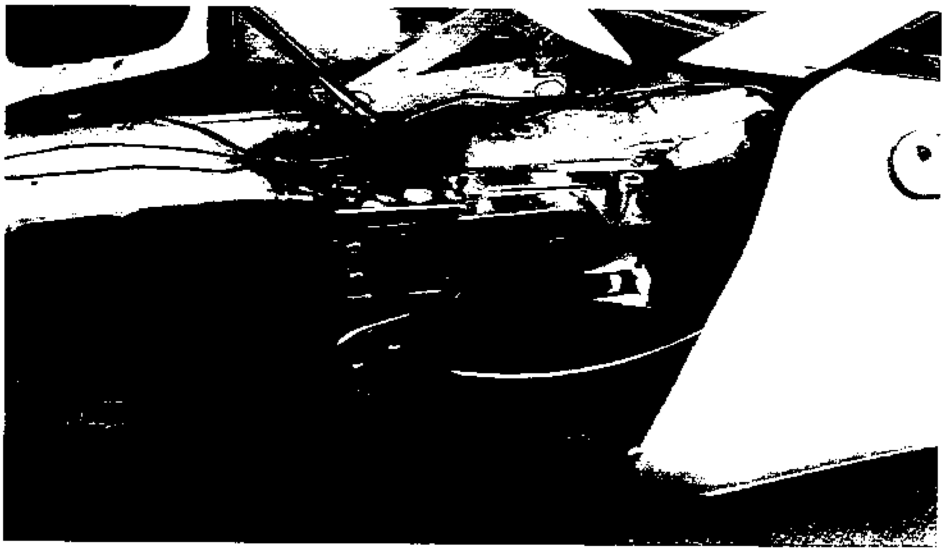


FIGURE.3.8 LAMBO HINGE OF METAL KING.Inc.

The mechanism consists of a chassis mounting plate securely fastenable to a vehicle frame; a swingarm securely fastenable to a vehicle door; a bi-directional rotation mechanism allowing motion of the swingarm in a horizontal plane and a vertical plane relative to the chassis mounting plate; and a sag adjuster screw guide mechanism, the sag adjuster screw bearing against the sag adjuster screw guide mechanism when the swingarm is rotated in the horizontal plane.

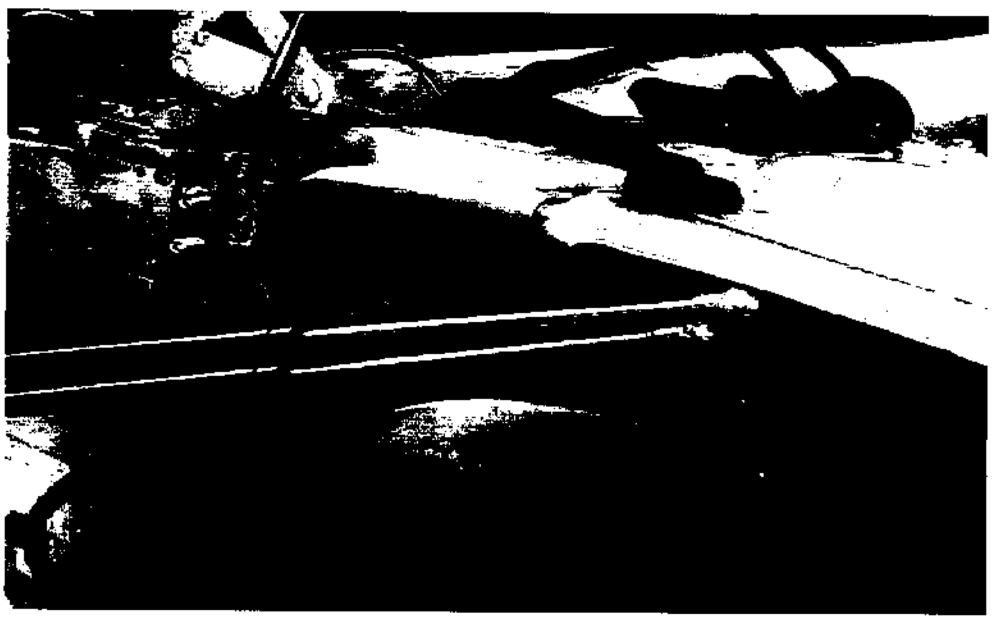


FIGURE.3.9 GAS CHARGED SHOCKS FOR LIFTING THE DOOR.

Usually 2 suspensions are used to lift the door. Their mounting position depends on the type of the car door. For example the above figure is the side view of a Mitsubishi 3000 gt. Here the suspension system is mounted over the tire. In the Indian cars however they will have to be mounted just below the bottom hinge after it is removed. The suspension is usually a gas charged shock absorber. They are connected to the door and car body by means of ball joints.

3.4.1 Lambo Door Conversion Technique and Mechanism:

There are usually two ways to convert ordinary stock doors into scissor doors. The techniques and methods are explained as follows.

Method 1:

The first method would be to purchase the original Lamborghini hinges and alter the car door accordingly. The hinges are of course difficult to obtain and there are very few skilled mechanics in our country to do the work. Also each hinge would cost around $400 per piece.

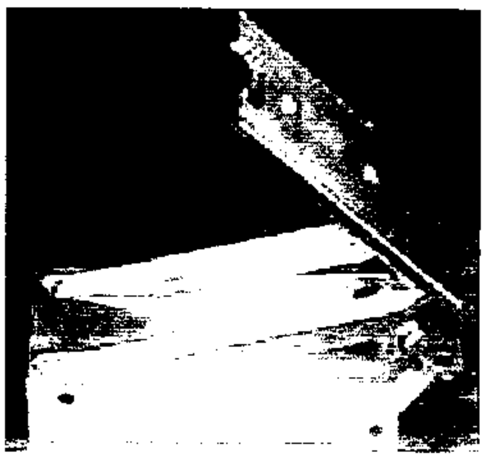


FIG.3.10 ORIGINAL LAMBORGHINI HINGE.

The advantage of this method is that it does not offer problems after the installation is done. Cars which reproduce Lamborghini style doors using these hinges are usually convincingly sturdy.

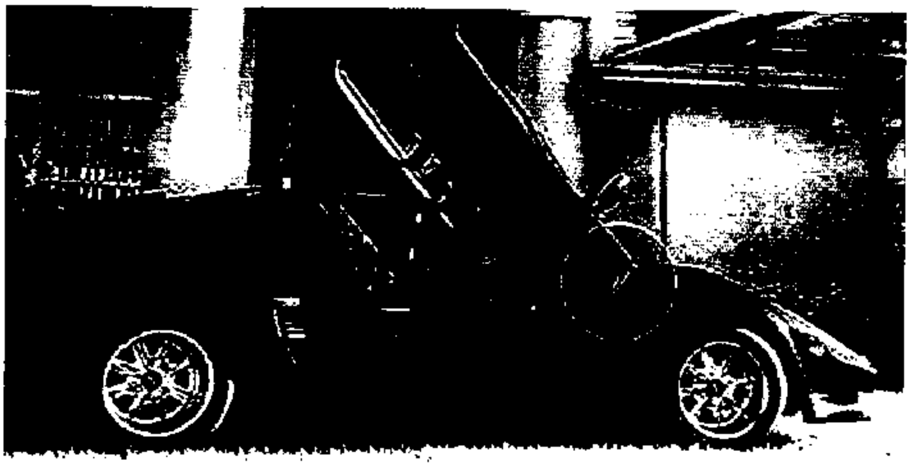


FIG.3.11 CAR FITTED WITH LAMBORGHINI HINGE.

The installation kit that compliments the lambo door hinge is shown below. The installation kit includes other than the hinge two shock absorbing struts, two blocks for installing the struts on the floor of the car and one on the door itself to incorporate the ball joint with the shock absorber. Like in Indian cars here too a lot of work is needed to be done in the car body itself. This includes shaving the a-pillar, changing the door seating or altering the design of the door itself.

FIG.3.12 THE INSTALLATION KIT.

Method 2:

Alternatively another way of installing scissor doors economically is by allowing the door to swing out a little before moving up. The hinge used here is obtained from rear door hinges of cargo vans. To install this type of door hinges, the following parts are needed:

- Two gas shocks - that work by switch (about 8 inches in length, 2 shocks – 1 per door)
- Steel tubing to reinforce the door
- Thick steel sheet metal

Step 1: One shock is mounted onto a plate at the bottom front corner of the drivers' door, mounted onto a flat plate that is welded to the floor/door structure of the car, under the carpet. The shock is not seen when the door is closed, the shock goes inside of the door and there is a plate welded to the door that also mounts to the shock at the tip of the skinniest shaft.

Step 2: The door is reinforced for support. The fenders are taken off to do some cutting, post welded on about 2X3 square tube, then GMC or Ford E rear cargo doors hinge. Some of the fender is cut off and is added to it like 180* flat bar.

FIG.3.13 DOOR WITH HINGE FITTED.

Step 3: The switch is hit so that the door slides out on that shock. Now comes the pushing up part. The other shock is mounted to the same plate, but it is about 12 inches long and runs up parallel to the door beside the seat and mounts to the door at the end of the shock. For heavier doors, a stronger gas shock above 180psi is used. A shaft is made to the door so that when the door pops out the shock slides on the shaft then when the door is popped out it catches and pushes the door open.

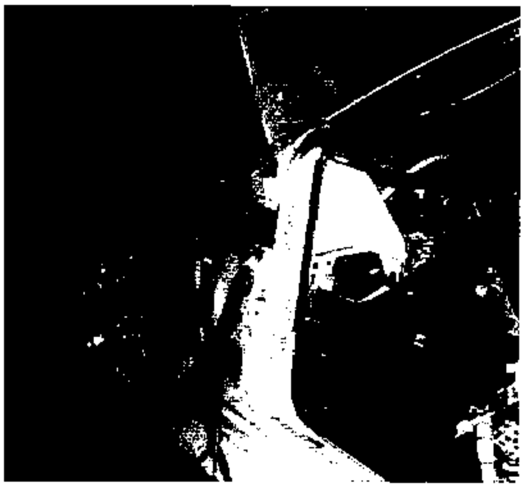


FIG.3.14 DOOR WITH FRONT COVER OPEN.

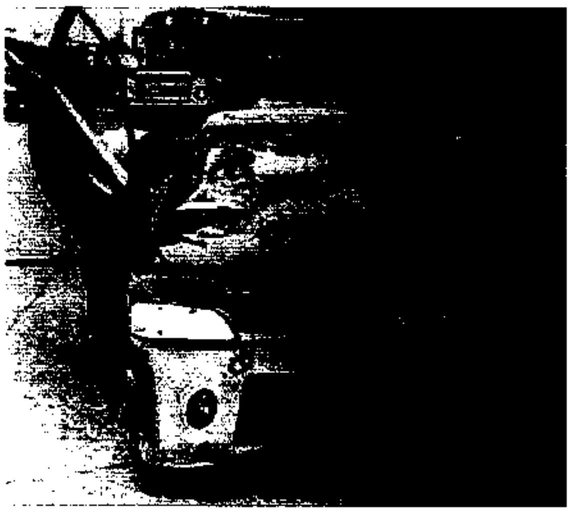


FIG.3.15 THE SCISSOR DOOR WHEN OPEN.

3.4.2 Details about the gas shocks:

The gas strut/shock is used to help support the door in the upright position. The stronger the shock, the more support the door has. For Lambo Door conversions, it is recommended to use struts of capacity 180psi and greater. Struts are relatively cheap. The strut has to be at least 8-10inches in length. A longer strut is used depending on how high the door will swing up. The farther the strut is mounted down the door, the longer the strut will need to extend. So the door needs to be analyzed and the place where the strut has to be mounted on the door and on the chassis of the vehicle is determined. Before choosing a pair of struts, it will need to make sure that they are long enough to reach from the mounting position on the chassis to the mounting position on the door when the door is fully extended. Also, they must be very strong. The stronger they are the better it will be. The strut is mounted further down the door away from the hinge when the door is found not staying upon its own. This will require less force to lift the door. If this still doesn't help, or if the strut cannot be positioned any lower, a stronger set of struts or another strut is used.

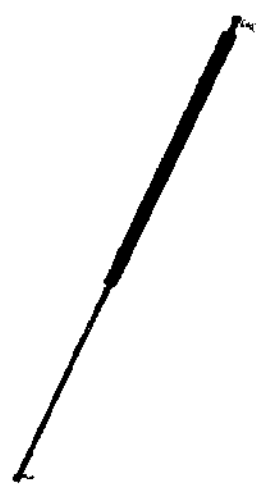


FIG 3.16 GAS SHOCK.

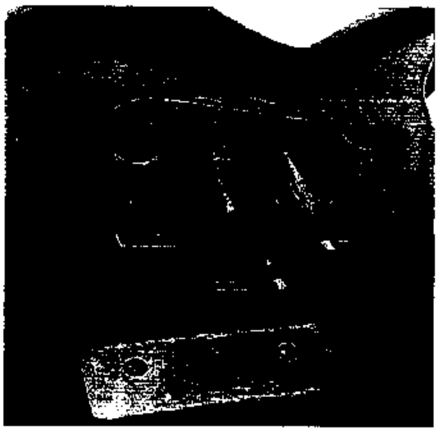
3.4.3 Converting the door latch – Keeping the Lambo door closed:

Step1: At this stage, it is needed to have the door mounted and the gas strut installed and working. The door needs to go up easily and smoothly (on its own or with a little help). When the door is shut everything needs be aligned properly, and care is taken to make sure that the door shuts tightly against the door seals to prevent leakage.

Step2: Previously, the door latch probably consisted of a striker pin mounted to the vehicle and a latch in the door with a horizontal opening to accept this striker pin. Now the door will be closing vertically and so the latching system will have to be reconfigured.

Step3: The door should still be apart from the hinge and strut installation. So it is seen how the latch works. Would it be possible to use the existing latch with a little cutting, welding and engineering? A possible solution would be to cut the latch out of the door and engineer a way for it to mount vertically within the door. The striker pin is relocated on the vehicle.

Some of the existing latches specifically designed for Lambo door applications are given below:



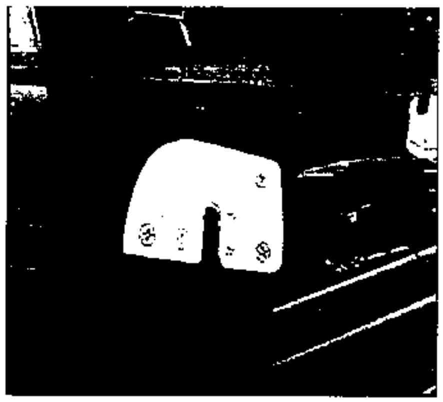


FIG.3.17, FIG 3.18 ALTERNATE LAMBO DOOR LATCHES.

To install them, the existing latch is cut out, taking note of exactly how it functions. Then the new latch is welded, the cutting and welding operation is done to install the new striker pin as well. The end of the door is modified to allow the striker pin to pass by without hitting the door. The end of the door is modified as shown in the picture below to allow the striker pin to pass by. Shaving most of the end of the door, like in the picture below will produce the best results. If a groove is cut up the middle of the end of the door, then the door must swing perfectly along that axis. For example, if a groove is cut straight down the middle of the end of the door, then the door must swing perfectly up and down in order for the striker pin to pass through. If there is any flex at all in the door, the pin will scrape the door, chip the paint and maybe even get stuck from time to time. So it is definitely best to shave the entire area on the end of the door like in the picture below:

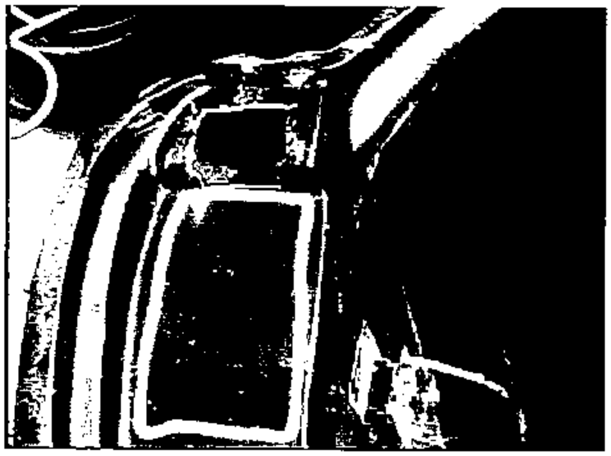


FIG.3.19 SHAVED END OF DOOR.

3.4.4 Installing a bolt-on vertical door kit:

Removing the stock door hinge:

First the fenders are removed. The top bolts are located under the hood where the fender wraps over from the side. There will be bolts on the bottom of the fender, the front, and possibly some in the back where the door opens. All the bolts are removed and the fender is pulled back and out carefully. When the fender is off, it is seen whether the door has the mechanism that helps keep the door part way or fully open. This is usually located half way up and between the front of the door and the body. The mechanism can be pushed into the door or may need to be removed completely, after the pin is knocked out. Next the door is closed and the top door hinge is removed. The door should not be operated at the absence of both the hinges.

a. Preparing the car body to fit the kit:

The way that the lambo door mechanism needed to be placed to fit it tight against the body and the door is analyzed. The seams that meet under the fender may stick out a ways and will need to be ground down until it's flush with the sheet metal of the body. Then the mechanism is welded to the body minimally so that it can be removed. Then the fender is fitted with its back up to the body to see the problems that may arise. Three possible issues are if it will fit under the fender without hitting. How close it comes to the fender when it swings out is another issue. This is due to the different pivot point used and can't be changed. This movement can be limited by two Allen set screws. The fender may need to be trimmed or bent to allow space for the arm to swing over. The third issue is to watch the placement where the flange is welded to the door. The lambo mechanism will need to clear the wire plug-in block for the door. The wires may need to be pulled through the rubber grommet farther. This is to reach the door when extended upward; the wires need to be disconnected until the door is installed. It is seen that the fender is cleared when the mechanism is moved out.

b. Welding the kit mechanism:

Some 1′ strips are welded around the lambo mechanism, preferably at least one per side of each flange. Now the bottom door hinge is removed carefully. Slowly the door is opened while supporting it. The door will probably drop down a few inches as it comes out. The Allen screw is set to adjust this height. Now the weight of the door is supported and carefully the door is lifted out and up. It will be heavy without any help from the shocks. So care is taken when it is set down and closed. The door is slammed fast to avoid any damage. Then the welding process is continued.

c. Incorporating the suspension system:

This next step will take two people. Help of someone is sought to extend the modified door all the way up. The shocks with the ball end connectors already connected are placed at the distance that they will be in when they are screwed into the arm. The positions of the holes for the ball ends are marked. Some space is left between them so that the shocks don't bind together. If the holes are not right, one of the shocks will have to be compressed. These shocks are special and are very difficult to compress. Care is taken to have the holes right. The metal is thickening up with extra spread out weld or a large fender washer is added to reinforce the area if needed. Then door is extended up and the shocks are connected. Now the upper most height that the door swings up was adjusted. If it swings up too high it may smack into the fender. A comfortable spot is found by testing it out. After the shocks the bottom door limit was adjusted again. The fender or ground effects may need to be cut and modified now to make room. This Lamborghini door kit installation takes three or four days with experienced fabricators.

CHAPTER 4
PRODUCTION PROCESSES

CHAPTER 4
PRODUCTION PROCESSES

4.1 WELDING – AN OVERVIEW:

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the *weld puddle*) that cools to become a strong joint, but sometimes pressure is used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces.

4.1.1 Welding processes

Arc welding

These processes use a welding power supply to create and maintain an electric arc between an electrode and the base material to melt metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is sometimes protected by some type of inert or semi-inert gas, known as a shielding gas, and filler material is sometimes used as well.

4.1.2 Processes

Shielded metal arc welding

One of the most common types of arc welding is shielded metal arc welding (SMAW), which is also known as manual metal arc welding (MMA) or stick welding. Electric current is used to strike an arc between the base material and consumable electrode rod, which is made of steel and is covered with a flux that protects the weld area from oxidation and contamination by producing CO_2 gas during the welding process. The electrode core itself acts as filler material, making separate filler unnecessary.

The process is very versatile, can be performed with relatively inexpensive equipment and owing to its versatility, is well suited to shop jobs and field work. An operator can become reasonably proficient with a modest amount of training and can achieve mastery with experience. Weld times are rather slow, since the consumable electrodes must be frequently replaced and because slag, the residue from the flux, must be chipped away after welding. Furthermore, the process is generally limited to welding ferrous materials, though specialty electrodes have made possible the welding of cast iron, nickel, aluminum, copper, and other metals. Inexperienced operators may find it difficult to make good out-of-position welds with this process.

Gas metal arc welding (GMAW), also known as metal inert gas or MIG welding, is a semi-automatic or automatic process that uses a continuous wire feed as an electrode and an inert or semi-inert gas mixture to protect the weld from contamination. As with SMAW, reasonable operator proficiency can be achieved with modest training. Since the electrode is continuous, welding speeds are greater for GMAW than for SMAW. Also, the smaller arc size compared to the shielded metal arc welding process makes it easier to make out-of-position welds (e.g., overhead joints, as would be welded underneath a structure).

The equipment required to perform the GMAW process is more complex and expensive than that required for SMAW, and requires a more complex setup procedure. Therefore, GMAW is less portable and versatile, and due to the use of a separate shielding gas, is not particularly suitable for outdoor work. However, owing to the higher average rate at which welds can be completed, GMAW is well suited to production welding. The process can be applied to a wide variety of metals, both ferrous and non-ferrous.

A related process, flux-cored arc welding (FCAW), uses similar equipment but uses wire consisting of a steel electrode surrounding a powder fill material. This cored wire is more expensive than the standard solid wire and can generate fumes and/or slag, but it permits even higher welding speed and greater metal penetration.

4.2 SHOCK ABSORBERS:

4.2.1 Introduction

A **shock absorber** in common parlance (or damper in technical use) is a mechanical device designed to smooth out or damp a sudden shock impulse and dissipate kinetic energy. Shock absorbers must absorb or dissipate energy. One design consideration, when designing or choosing a shock absorber is where that energy will go. In most dashpots, energy is converted to heat inside the viscous fluid. In hydraulic cylinders, the hydraulic fluid will heat up. In air cylinders, the hot air is usually exhausted to the atmosphere. In other types of dashpots, such as electromagnetic ones, the dissipated energy can be stored and used later.
Despite what many people think, conventional shock absorbers do not support vehicle weight. Instead, the primary purpose of the shock absorber is to control spring and suspension movement. This is accomplished by turning the kinetic energy of suspension movement into thermal energy, or heat energy, to be dissipated through the hydraulic fluid.

Shock absorbers are basically oil pumps. A piston is attached to the end of the piston rod and works against hydraulic fluid in the pressure tube. As the suspension travels up and down, the hydraulic fluid is forced through tiny holes, called orifices, inside the piston. However, these orifices let only a small amount of fluid through the piston slowing down the piston, spring and suspension movement.

The amount of resistance a shock absorber develops depends on the speed of the suspension and the number and size of the orifices in the piston. All modern shock absorbers are velocity sensitive hydraulic damping devices - meaning the faster the suspension moves, the more resistance the shock absorber provides. Because of this feature, shock absorbers easily adjust to road conditions. The actions that are responsible for the ride conditions that are reduced by the shock absorbers include the rate of:

- Bounce
- Roll or sway
- Brake dive and Acceleration squat

Shock absorbers work on the principle of fluid. A typical car or light truck will have more resistance during its extension cycle then its compression cycle. The compression cycle controls the motion of a vehicle's unsprung weight, while extension controls the heavier sprung weight.

Compression cycle

During the compression stroke or downward movement, some fluid flows through the piston from chamber B to chamber A and some through the compression valve into the reserve tube. To control the flow, there are three valving stages in each of the piston and in the compression valve. At the piston, oil flows through the oil ports, and at slow piston speeds, the first stage bleeds come into play and restrict the amount of oil flow. This allows a controlled flow of fluid from chamber B to A. At faster piston speeds, the increase in fluid pressure below the piston in chamber B causes the disc to open up away from the valve seat.

At higher speeds, the limit of the second stage discs phases into the third stage orifice restrictions. Compression control is the force that results from a higher pressure present in chamber B, which acts on the bottom of the piston and the piston rod area.

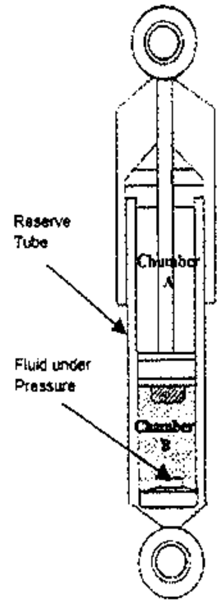


FIG 4.1 COMPRESSION CYCLE

Extension cycle

As the piston and rod move upward toward the top of the pressure tube, the volume of chamber A is reduced and thus is at a higher pressure than chamber B which has a lower pressure. Because of this higher pressure, fluid flows down through the piston's 3-stage extension valve into chamber B. However, the piston rod volume has been withdrawn from chamber B greatly increasing its volume. Thus the volume of fluid from chamber A is insufficient to fill chamber B.

The pressure in the reserve tube is now greater than that in chamber B, forcing the compression intake valve to unseat. Fluid then flows from the reserve tube into chamber B, keeping the pressure tube full. Extension control is a force present as a result of the higher pressure in chamber A, acting on the topside of the piston area.

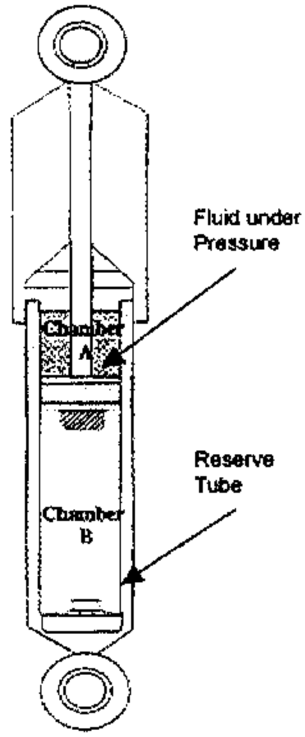


FIG 4.2 EXTENSION CYCLE

4.2.2 Shock Absorber Design

Mono-tube design

These are high-pressure gas shocks with only one tube, the pressure tube. Inside the pressure tube there are two pistons: a dividing piston and a working piston. The working piston and rod are very similar to the twin tube shock design. The difference in actual application is that a mono-tube shock absorber can be mounted upside down or right side up and will work either way. In addition to its mounting flexibility, mono-tube shocks are a significant component, along with the spring, in supporting vehicle weight. Another difference you may notice is that the mono-tube shock absorber does not have a base valve. Instead, all of the control during compression and extension takes place at the piston. The pressure tube of the mono-tube design is larger than a twin tube design to accommodate for dead length. This however makes it difficult to apply this design to passenger cars designed OE with a twin tube design. A free-floating dividing piston travels in the lower end of the pressure tube, separating the gas charge and the oil. The area below the dividing piston is pressurized to about 360 psi with nitrogen gas. This high gas pressure helps support some of the vehicle's weight. The oil is located in the area above the dividing piston. During operation, the dividing piston moves up and down as the piston rod moves in and out of the shock absorber, keeping the pressure tube full all times.

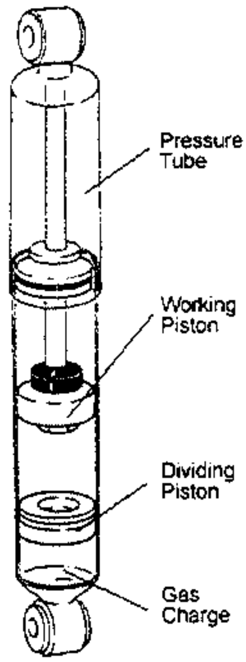


FIG 4.5 MONO TUBE DESIGN

Advantages:

- Can be mounted upside down, reducing the unsprung weight
- May run cooler since the working tube is exposed to the air

Disadvantages:

- Difficult to apply to passenger cars designed OE with twin tube designs.
- A dent in the pressure tube will destroy the unit

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CHAPTER 5

DESIGN AND FABRICATION OF LAMBO DOOR

CHAPTER 5
DESIGN AND FABRICATION OF LAMBO DOOR

5.1 ANALYSIS OF THE CURRENT STOCK DOOR HINGE:

Initially before designing the hinge mechanism the hinge of the stock door was studied. The car on which the door was to be fitted was Hyundai Accent GLS 2001 model. The door has two hinges near the top and bottom of the door. Both the hinges are of the same design and allow one degree of freedom. They allow rotational freedom along an axis on the hinge.

The design specifications of the stock door are listed below.

- Hinge Material: Mild Steel, C40
- Door Height: 105cm
- Door Length: 97cm
- Door weight: 23kg
- Door width at the maximum value: 18cm
- Bottom outside edge distance when fully opened: 110cm
- Door angle when fully open: 58 degrees

The two stock hinges in the car are of the same dimensions and material. Both the hinges have a stopper to prevent the door from swinging too wide. Another contraption used for this purpose is called checker. This is usually made of plastic and can be used to restrict the door swing within the complete range of door swing. This component is the first one to be removed before dismantling the door. The two hinges are subjected to shear load corresponding to the weight of the door and may vary according to other features like power windows. The two cotter pins are subjected to an additional torsional force due to the swinging of the door.

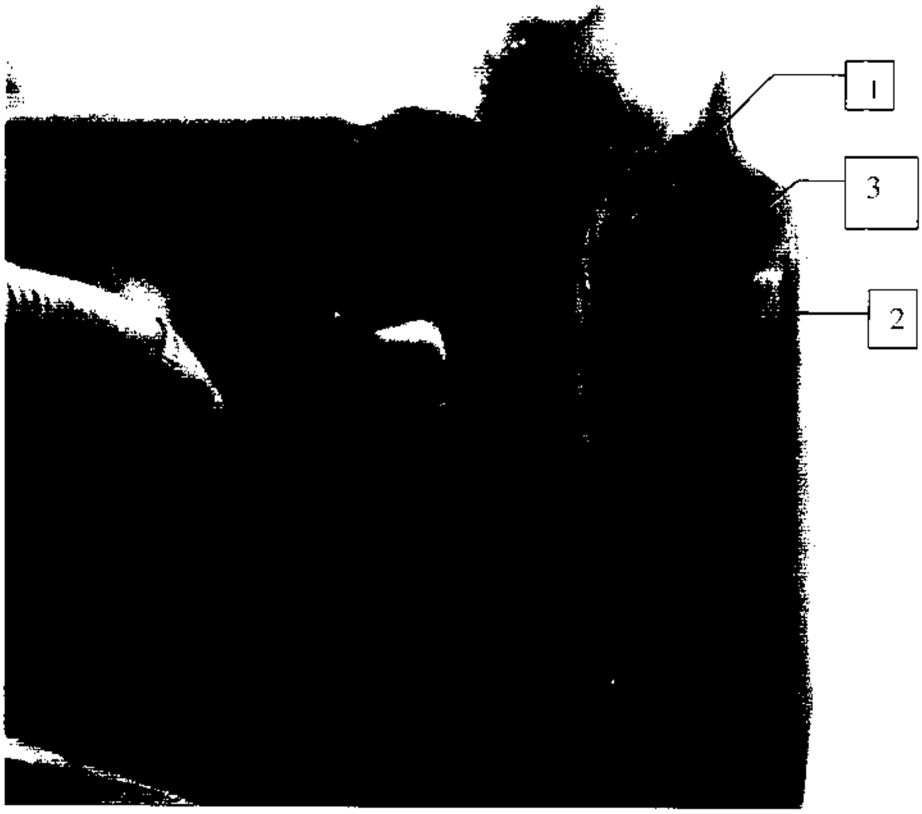

FIGURE.5.1 STOCK DOOR HINGE MADE OF MILD STEEL.

Part Description

1. **Hinge part connected to the car body.**
2. **Hinge part connected to the door**
3. **Stopper to check the door swing.**

5.2 INITIAL DESIGN:

From the outset designing the appropriate hinge was the challenge. The suspension design and mounting was fairly simple. The hinge had to allow both the swinging motion and swivel motion both with checks to prevent either motion to proceed above a certain degree. Initially a design was proposed to incorporate the swivel motion in the already used hinge. This was carried out in Indian Auto Works, Erode.

The first design proposed was based on the hinge of altered lambo doors use by 'vertical doors.inc'. It consisted of a groove that would slide the door of the car away from the car body. This would ensure that the door slides away from the car body in a parallel plane clearing all the knobs, handles and the A-pillar. Then the hinge simply needed to be rotated about a horizontal axis. As the stock hinge was quite expensive to meddle with, first a model of the hinge was made out of sheet metal. This ensured to check if our design would succeed. After our initial doubts about the design were clarified an original hinge for the car chosen was bought separately.

FIG 5.2 ALTERED DOOR HINGE WITH THE GROOVE

The new design involved apart from the groove a separate block that would slide with the bolt along the groove. At the end of the block near the door a hole was drilled and the clamp usually used to connect the door to the hinge was bolted with the block. Since this was but a trial all the machining processes were done with maximum tolerances. The cotter that is employed in the stock hinge to incorporate the door motion along a vertical axis was done away with. In its place a bolt was included which ran through the groove and the separate block mentioned above. The groove was made out of gas cutting and the block was machined separately so as to provide it sufficient clearance when the door is opened. The hole on the front side of the block was also drilled in the nearby lathe. The groove was cut on an idea that it will provide the clearance needed for the door to swing up without any obstruction. The bolt used was a self locking type.

5.3 FAILURE OF THE DESIGN:

After the prototype was developed certain shortcomings were understood. The stock door hinge was very sturdy owing to the fact that there is only one moving part in it. The cotter that allows the door to open in a predetermined arc, upto a certain level, made of mild steel did not allow any sagging. Sagging is the phenomenon of the door shifting from its position when the weight of the door is not supported effectively by the door. This may occur due to the deformation of the hinge due to the weight of the door. This phenomenon does not occur in stock hinge doors. However this was experienced in the new hinge design.

Another issue that forced abandoning the hinge design was the fact that unlike the cotter, the pin which had to move along the groove started wearing out soon. Choosing a wear resistant material for the hinge and pin would mean that lubrication would also need to be provided. A lubrication system could obviously not be fitted in the small place between the car frame and fender. The spring that on unlocking the door moved the door away by pushing the door through the groove could not be forced back from inside the car. This could however be achieved by having a two bar linkage connecting the spring and a handle in the door. Other than making the design complex, this made the entire process of closing and opening the door quite complicated. So this design had to be eliminated.

5.4 FINAL HINGE DESIGN:

In the new design the idea of changing the pivot point of rotation to change the displacement was understood. Incorporating this idea, the pivot point was shifted farther from the door than the original hinge. By this way the door only had to be swung a little to achieve the same displacement along the predetermined arc in the horizontal direction. This design also used only a single M12 bolt to incorporate the swivel motion.

The following components were designed separately and then assembled together. All the parts were made of mild steel C40, except the cotter and bolt that were made of cast iron C60. The cotter pin is used to swing the door out of the car body. The pivot point of the door's swing was shifted by another 6cm to increase the door displacement for the same angle of swing.

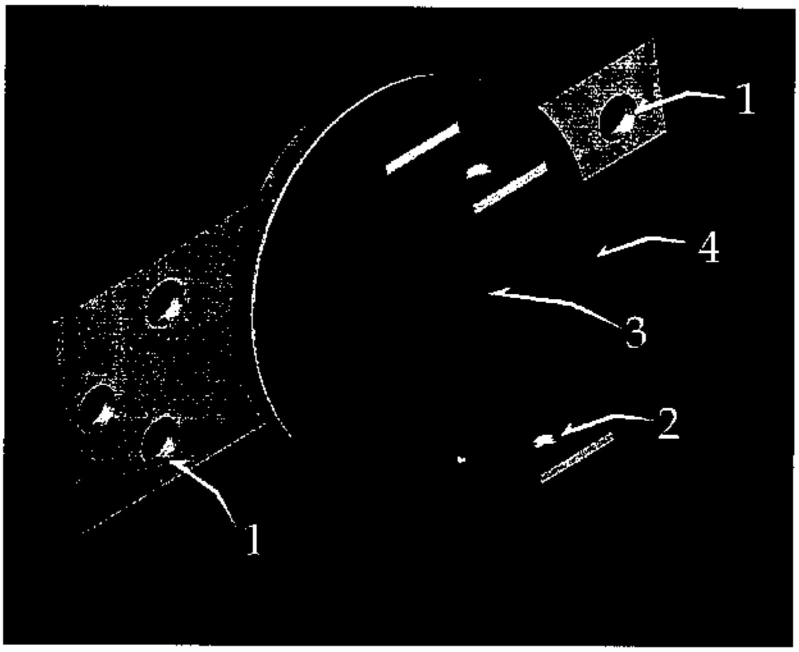

FIG 5.3 A VIEW OF THE HINGE MODEL CONNECTED TO THE CAR BODY.

1. M12 and M20 Bolts:

The first component was to be mounted to the car body frame. The bolts used for the stock door hinge were retained. So to fit the hinge to the same set of holes, two separate strips of metal that would attach the hinge to the same holes were welded.

2. Cotter Pin Holes:

The 6mm holes are used to mount a cotter about which the door is supposed to swing. The height of the cotter pin is 55mm and diameter 6mm. The cotter pin is made of C65 steel. This cotter pin is subjected to torsional shear stress and is a vital component of the design.

3. M20 Bolt

The bolt is the axis of rotation of the door vertically. The bolt provides additional support to the hinge by supporting it with the car body frame. This is also made of C65 and is the most important component of the design.

4. Flange

The two flanges of diameter are made of mild steel C45 and consists of two components. The first one is stationary and is fixed to the body of the car. The second part also of the same material and dimensions rotates along with the bolt and is used to lift the door up.

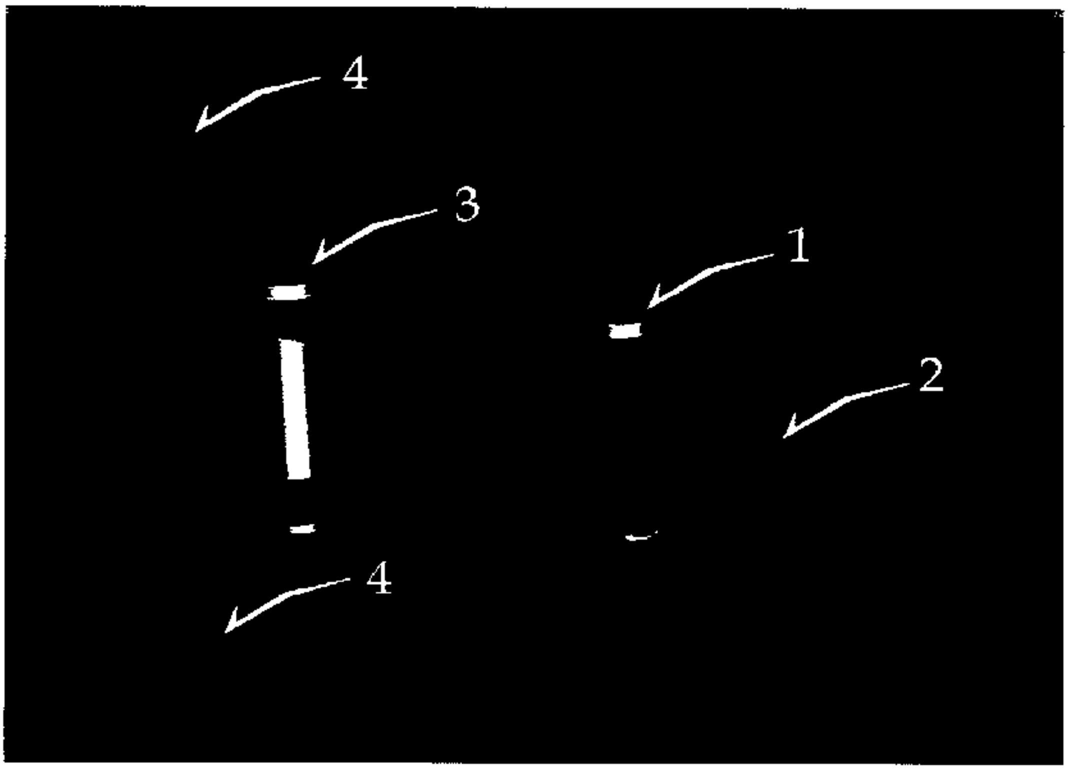

FIG 5.4 A VIEW OF THE HINGE COMPONENT CONNECTED TO THE DOOR.

1. Cotter Pin:

This cotter pin forms the pivot for the door swing. This part is analyzed to validate the design. The same cotter pin is found in the stock door hinge too.

2. Stopper block:

The block of metal marked in the figure is used to control to the door swing. Based on the dimensions of this block the swinging of the door is restricted. After a certain degrees it is obstructed by the flange shown in the above figure.

3. Supporting Cotter Pin

The second cotter pin is of the same dimensions and material as the first, the only difference being the use. This pin holds together the two components of the hinge with the weld and provides support for the mechanism.

4. Holes on the hinge

These holes correspond to similar holes along the side of the car. It is threaded and is used to connect the hinge mechanism to the door. The setup is used to retain the originality and reusability of the stock door.

5.5 DESIGN CALCULATIONS:

Change in displacement:

We know that the displacement changes with change in turning radius.

$L = R*\Theta$

In this case the angle of rotation is denoted by Θ.

The value of Θ is limited to around 40 degrees to prevent the door from swinging too wide. The radius of rotation is incremented to achieve a marginal increase displacement.

Initial Distance between cotter pin and door hinge = 8 cm.

The distance between cotter pin and door hinge = 14 cm.

The door radius in the previous case = 97 cm.

The door swing radius in lambo hinge design = 103 cm.

Angle of swing of the door = 40 degrees.

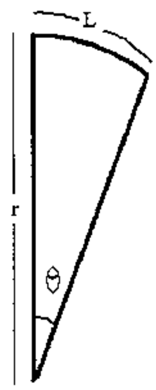

FIG 5.5 DISPLACEMENT FOR ANGULAR MOTION

Displacement of the door in previous case = R * Θ

= 0.97 * (40 * pi) / 180.

= 0.6768m

Displacement of the door in new design = 1.03 * (40 * pi) /180.

= 0.7187m

Change in displacement = 71.87 – 67.68

= 4.19 cm.

The angle of swing of the door for the same displacement is calculated to understand the optimization achieved.

Θ = Displacement / Radius of Rotation

= 0.7187 / .97

= 0.7403 radians

In degrees Θ = 0.7403 * 180 / pi.

= 43 degrees (approx.)

The optimization achieved is that the door does not have to swing as much as in the previous case. Door clearance required before moving the door upwards is 7 cm.

This clearance is achieved by just 40 degrees unlike in the previous case where the angle of swing is higher.

This is the only aspect of design that was decided beforehand. The hinge was then designed using Pro-E and after being validated using ANSYS, the hinge was manufactured.

Determining Centre of Gravity

To validate the design in ANSYS the centre of Gravity of the door needed to be calculated. Considering the basic geometric structure of the door the centre of gravity of the door was calculated as follows.

Part 1:

X1 = b/3 = 47/3 = 15.7 cm.

Y1 = h/3 = 40/3 = 13.3 cm.

Area, A1 = ½*b*h = 940 sq.cm.

Part 2:

X2 = l/2 =57/2 = 28.5 cm.

Y2 = b/2 = 47/2 =23.5 cm.

Area, A2 = 57*47 =2679 sq.cm.

Part 3:

X3 = l/2 = 97/2 = 48.5 cm

Y3 = b/2 = 62/2 = 31 cm

Area, A3 = 97 * 62 = 6014 sq cm.

According to the method of moments,

X' = (a1x1 + a2x2 + a3x3)/(a1+a2+a3).

Y' = (a1y1 + a2y2 +a3y3)/(a1 + a2 +a3)

Substituting the values we get,

X' = 39.74cm

Y' = 27.19cm

Centre of Gravity of the door = (39.74, 27.19)

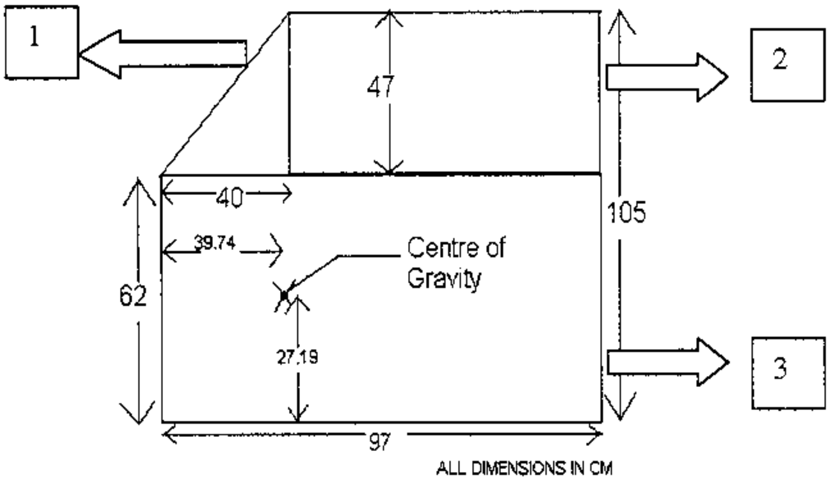

FIG 5.6 MODEL DIAGRAM OF DOOR

Other technical details required for the design and analysis of the hinge.

- Door Height: 105cm
- Door Length: 97cm
- Door weight: 29 kg
- Door width at the maximum value: 18cm
- Bottom outside edge distance when fully opened: 110cm
- Door angle when fully open: 58 degrees
- Door hinge material: Mild Steel, C40.
- Cotter Pin material: High Carbon Steel, C65.
- Tensile strength of hinge, C40 steel: 600 kN/mm^2
- Yield Strength of hinge material, C40 steel: 380 kN/mm^2
- Tensile Strength of cotter pin, C65 steel: 750 kN/mm^2
- Yield Strength of C65 steel: 430 $kN/mm^{2.}$

5.6 FABRICATION OF SCISSOR DOORS.

5.6.1 Manufacturing the hinge:

In the hinge mechanism two motions needed to be incorporated. The first was the swing motion and the second was a swivel motion. The objective of the hinge design was to make it an alteration that can be switched with the stock door mechanism when needed. So the same hinge bolts of the original door were retained. The component of the hinge that was to be connected to these bolts was also the one that needed to revolve the door vertically. So two circular plates of mild steel were machined and these two plates were bolted together by a bolt. The circular flange close to the car's body was bolted to the car using the same holes of the original hinge. To make this engagement compatible another plate of mild steel was welded together with the circular flange.

The next component of the hinge was the component connected to the door. A similar shaped hinge was machined to fit in the same holes as the stock hinge joint. This part too was made out of mild steel. Then the swinging action of the stock door needed to be replicated. For this a cotter pin like the one use in stock hinges was manufactured out of cast iron. This cotter pin was however repositioned away from the original position of the cotter pin. The objective was to increase the displacement for the same angle of swing. This cotter pin was then connected to the hinge component at the door end by means of two metal strips. The metal strips were not straight but rather curved to prevent it from being obstructed by the front fender. A cotter pin of the same dimensions as the one used as a pivot point for swinging the door was used near the rod end where the metal strips meet the hinge component near the door end. The purpose of this was to support the lengthy metal strip.

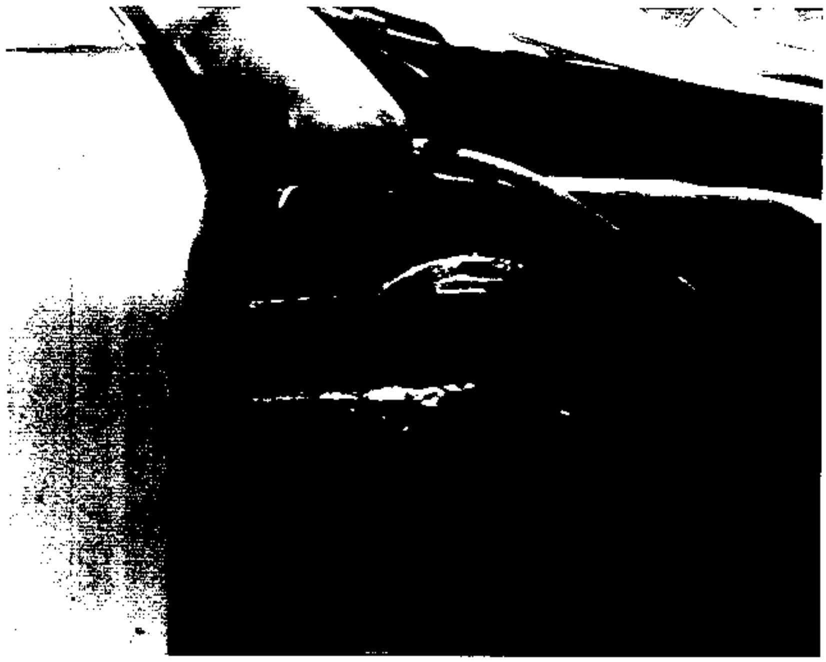

FIG 5.7 A VIEW OF THE LAMBO DOOR HINGE MECHANISM

At this point however the angle of swing had to be limited to the smallest value that would clear the knobs and handles on the inner side of the door. Also the angle of swivel too had to be limited to prevent the door from hitting the door. Two blocks of metal were welded with the metal strips and circular flange to control the angle of swing and swivel respectively. The design of the door was analyzed using ANSYS and the centre of gravity of the door was determined. Using the software the angle of swivel that would not unbalance the door was estimated. This angle left sufficient space for entering and exiting the vehicle. The angle of swing that was to be allowed was found by trial and error method after installing the hinge. Another block of metal was welded with the metal strip, the length of which determined the swing of the door. As mentioned earlier all the welding processes were done by arc welding method.

FIG 5.8 ANOTHER VIEW OF THE LAMBO DOOR HINGE

5.6.2 Suspension System:

The suspension systems normally used in automobiles were studied and gas charged shock absorbers were chosen as the appropriate choice. Before ordering a design specific shock absorber, the stock shock absorbers presently used in Indian cars were investigate to check if they suited the purpose. Consequentially the suspension used in Maruti omni fitted the door specifications perfectly. The suspension when mounted needed to support and move the door in 2 directions. The door before being pushed up swings out for a considerable distance. The shock absorber before pushing the door outwards must move along with the door. So the two ends of the shock absorber will exhibit different degrees of freedom. The lower end which is connected to the floor of the car exhibits rotational motion along two directions and the end connected to the car door exhibits rotation along one direction. The suspension is so mounted such that it moves the door outside and then lifts it.

5.7 ADVANTAGES ACHIEVED

The door's positional dimensions were noted before and after installing lambo door.

Before installing Lambo doors

- Door width when fully open: 106 cm
- Door Swing Angle: 58 degrees.
- Door to door width when closed: 165cm
- Door to door width when fully opened: 377cm

After installing the Lambo doors

- Door width when fully open: 85cm (at outer edge)
- Door Swing Angle: 40 degrees
- Door swivel angle: 44 degrees (adjustable upto 60 degrees)
- Door to door width when fully opened: 335cm

From the above data one can infer that the difference in length of door swing is 37cm. This is roughly 23% of the car's width. This difference is contributed solely by the Lambo doors.

The fringe benefits of this project are,

- The user does not have to continuously hold the door to prevent it from reaching its full length as in stock doors.
- The door's projection is not as much danger to the overtaking traffic as a stock door.
- The aesthetic appeal of the car is considerably higher in this case.

CHAPTER 6

DESIGN VALIDATION USING ANSYS

CHAPTER 6

DESIGN VALIDATION USING ANSYS

6.1 INTRODUCTION TO ANSYS

The ANSYS program is a powerful multipurpose finite element tool that can be used in a variety of industries such as automobiles, railways, electronics, power generation and power transmission. The ANSYS program has many finite-element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. The analysis guides in the ANSYS documentation set describe specific procedures for performing analyses for different engineering disciplines. ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping. With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

In the hinge design only two components had to withstand the load. One is the cotter pin based on which the door swings and the other is the bolt which forms the axis of swivel. The two components are analyzed using ANSYS in the following pages one by one.

6.2 COTTER PIN

6.2.1 Pre Processing

Geometry

The modeled cotter pin, in Pro/ENGINEER software is stored in IGES format, is imported to the ANSYS workspace. This is done by using import option selected using the following GUI path.

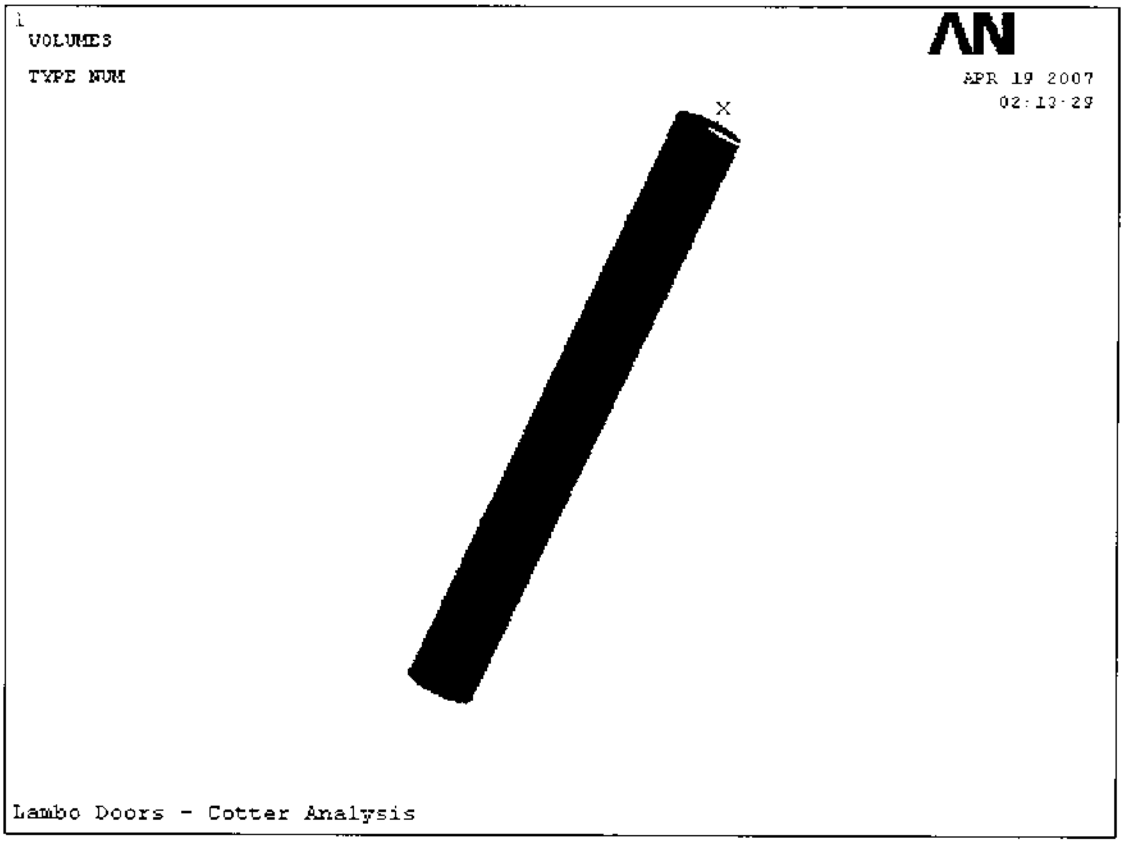

FIG 6.1 GEOMETRIC REPRESENTATION OF COTTER PIN

While importing this model there was no data loss occurred because of conversion. The model is checked for its volume.

Defining Element Type

The ANSYS element library contains more than 150 different element types. Choice of suitable mesh is vital to the accuracy and economy of the output of finite element analysis. While going through the literature available in ANSYS element module, it was found that the following elements were suitable to the nature of load which we dealt with our analysis.20-Node Non-Layered Structural Solid (3-D SOLID186) element was suitable to be applied to the analysis, since it could take up pressure and force as input.

Non-Layered Structural SOLID 186

20-Node Non-Layered Structural Solid (3-D SOLID186) element was suitable to be applied to the analysis, since it could take up pressure and force as input.

Geometry of SOLID 186

SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities.

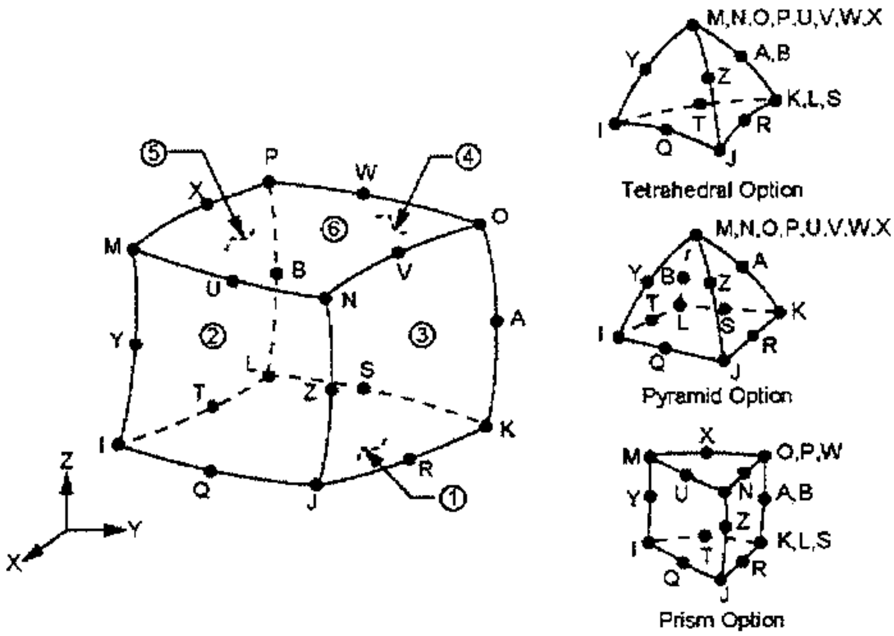

FIG 6.2 GEOMETRY OF SOLID 186

It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials.

Defining Material Properties

The Cotter pin is made with High carbon Steel with the following properties. The steel grade used is C 15

S. No.	Property	Value
1.	Ultimate tensile strength	430 N/mm^2
2.	Modulus of Elasticity	2.08 X 10^5 N/mm^2
3.	Poisson's ratio	0.3
4.	Yield Stress	240 N/mm^2

TABLE 6.1 MATERIAL PROPERTIES

6.2.2 Meshing the Model

The imported model is meshed wisely for the analysis. Mesh selection is very tedious process.

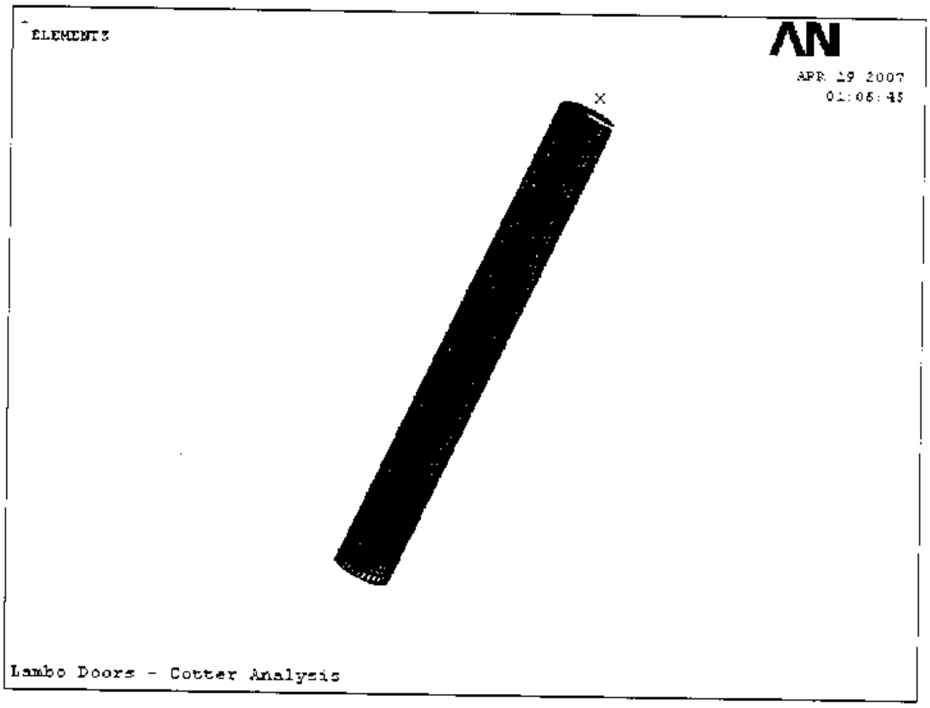

FIG 6.3 DISCRETIZED MODEL

In this case SWEEP mesh is selected and the imported model is meshed. Smart sizing gives the mesher a great opportunity to create reasonably shaped element during automatic element generation. In the mesh tool Smart sizing option is enabled and set at value 1. With that fine sizing the total no of elements and nodes what we got is mentioned below.

These are the major steps which we have to do in the pre-processing stage of this finite element analysis of COTTER PIN.

6.2.3 Load Calculation

In this section the exact load which will act on the Cotter Pin at the time of opening of the door is listed down. The various components of force acting on the cotter pin were calculated and explained individually. Two points one the cotter having definite area is taken up and load analysis is done. Two pieces each of area 47.1 sq.mm is taken up and the load calculation is made. The cotter pin is divided into two halves and a single half is taken for analysis.

Weight of the door = 30 Kg.

The load acting on the pin = 30*9.81 = 294.3 N.

Area of action of force = 3.14* 6*5/2 = 47.1 sq.mm.

The pressure acting on the pin = load/2*area = 3.12 N/mm^2.

The figure shown below depicts the load analysis at the specified portions of the cotter pin.The load analysis was made by constraining the ends of the cotter pin to be fixed.

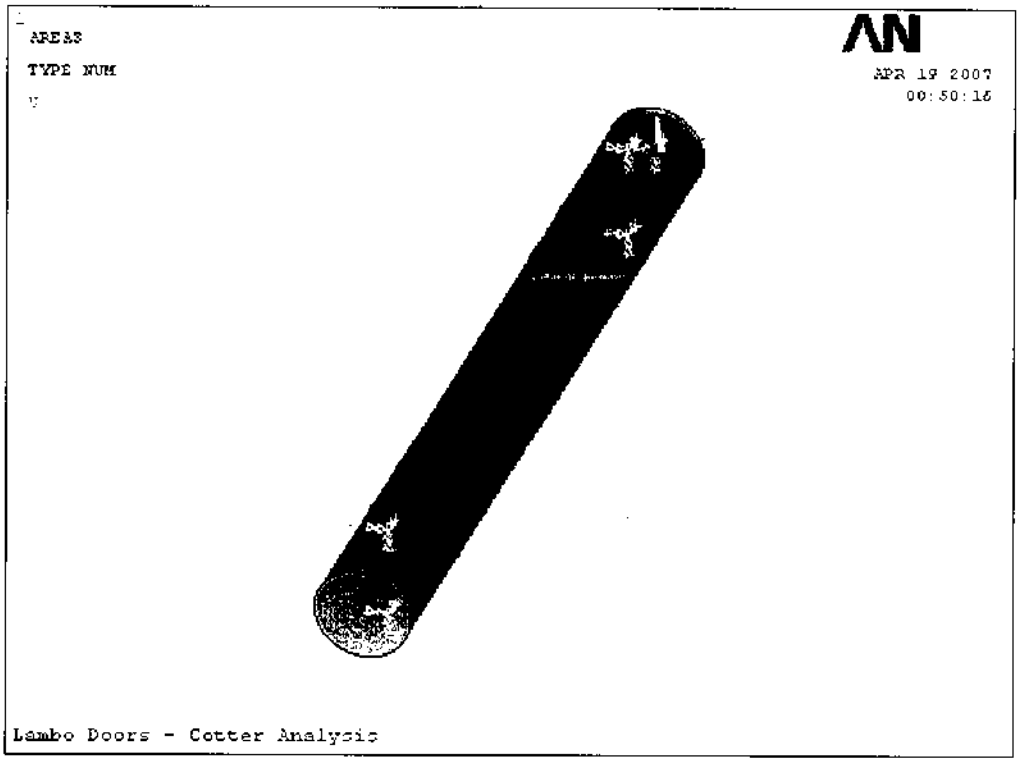

FIG 6.4 LOAD ANALYSIS

6.2.4 Post Processing

Result Plots

After the solver completes the analysis it will calculate nodal and elemental results and will keep all the data ready for viewing. We can plot those data by selecting the following GUI path.

General Post Processing → Plot Results → Contour Plot → Nodal Solution.

A window will appear in which we can find various parameters. By selecting any of the required one, ANSYS will plot those results.

Displacement Plots

The displacement of the nodes created in the cotter pin because of load is plotted. The displacement in the X, Y, Z axes and the vector sum plot were shown below. All the results shown below belongs to the last sub step.

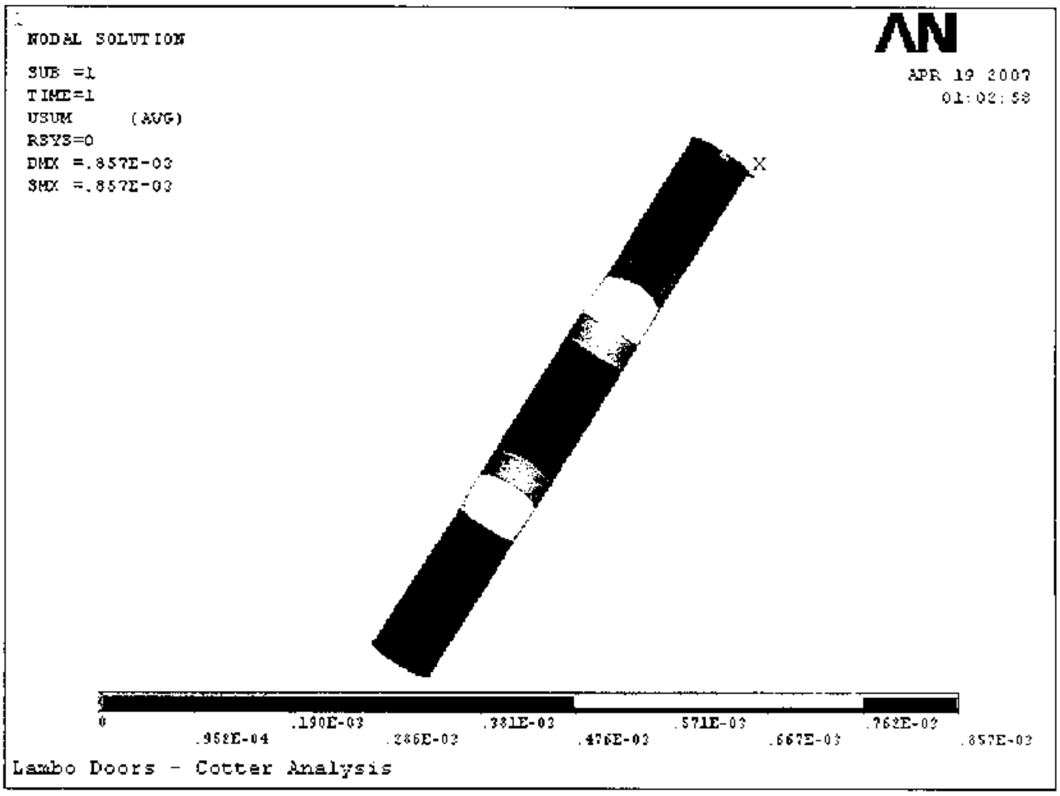

FIG 6.5 DISPLACEMENT VECTOR SUM

Stress Plots

Stress developed in the cotter pin in various axes because of load applied were plotted and shown below.

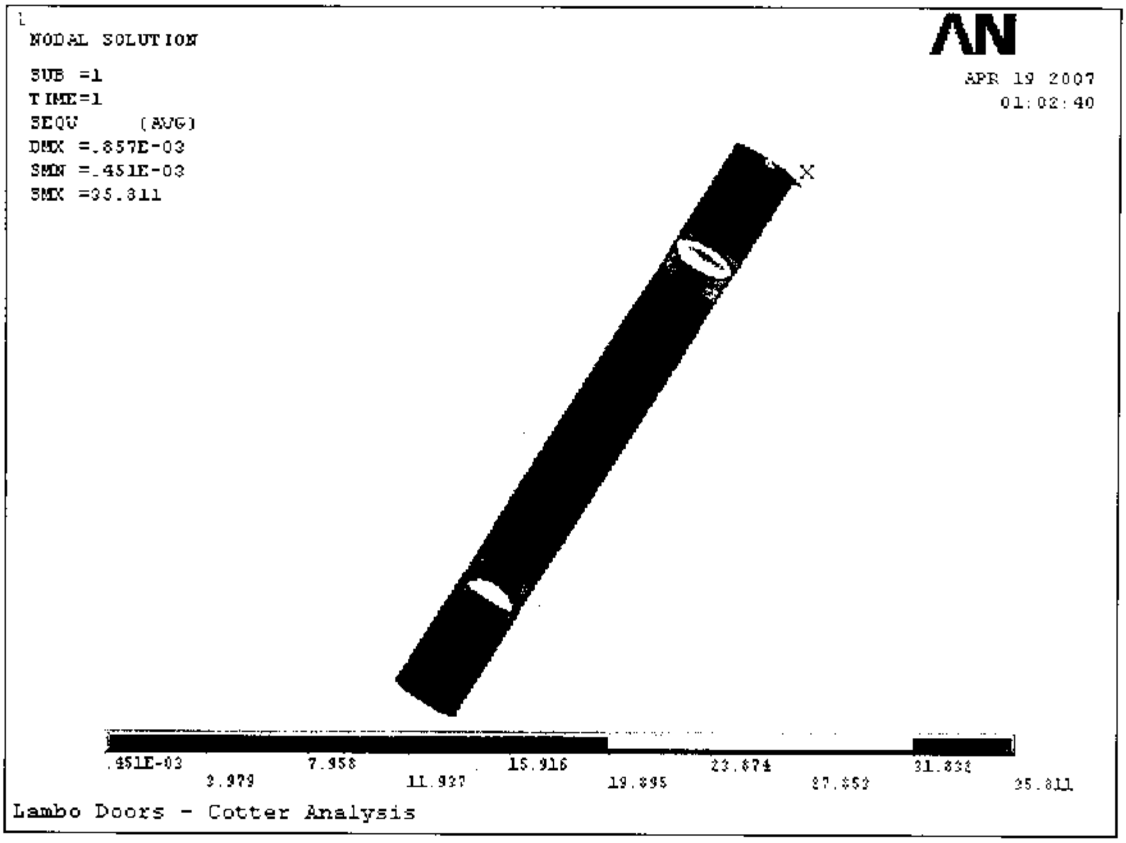

FIG 6.6 STRESS ANALYSIS

Thus the various result plots were shown above. It is seen from the data book that the yield strength of the cotter material is found to be 240 N/mm^2.The analysis made shows the stress value to be 35.811 N/mm^2.Since this stress is well below the yield strength of the cotter material the design is safe.

6.3 ANALYSIS OF BOLT

6.3.1 Preprocessing

Geometric Model

The modeled flange bolt, in Pro/ENGINEER software is stored in IGES format, is imported to the ANSYS workspace. This is done by using import option selected using the following GUI path.

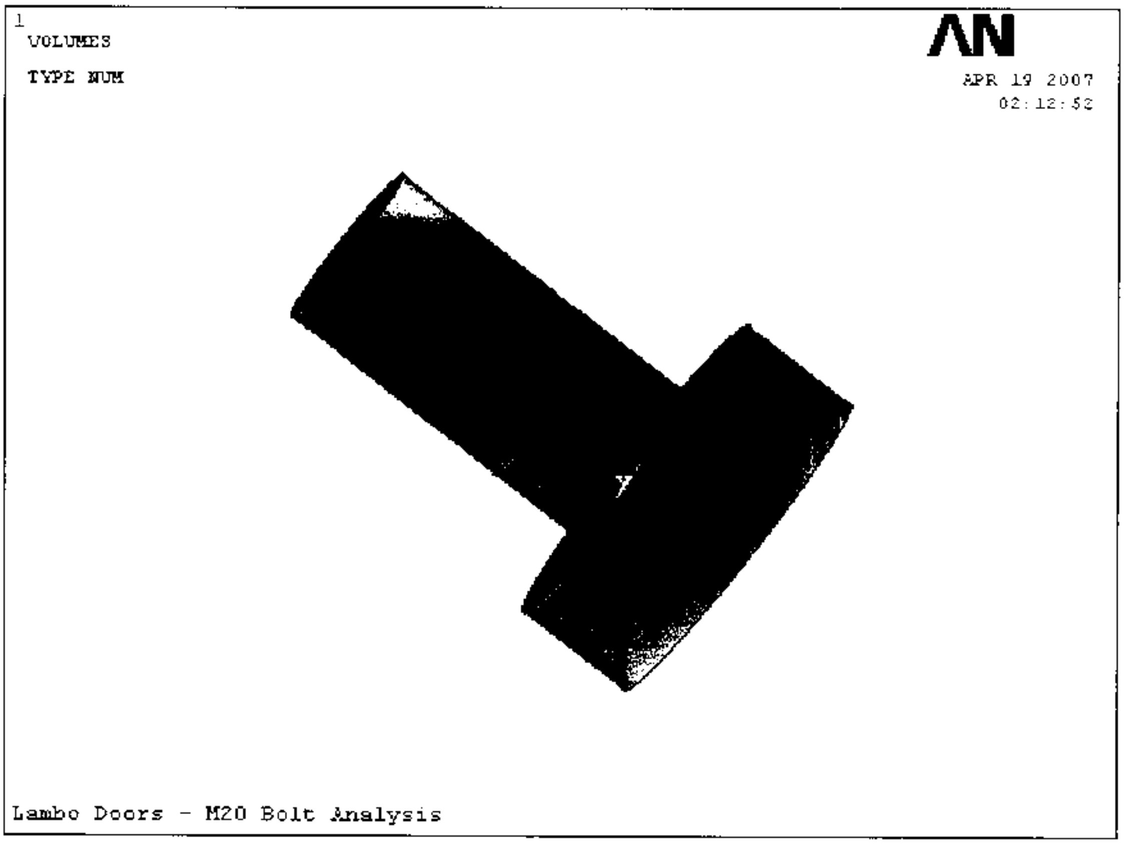

FIG 6.7 GEOMETRIC REPRESENTATION OF FLANGE BOLT

While importing this model there was no data loss occurred because of conversion. The model is checked for its volume.

Defining Element Type

The ANSYS element library contains more than 150 different element types. Choice of suitable mesh is vital to the accuracy and economy of the output of finite element analysis. While going through the literature available in ANSYS element module, it was found that the following elements were suitable to the nature of load which we dealt with our analysis.20-Node Non-Layered Structural Solid (3-D SOLID186) element was suitable to be applied to the analysis, since it could take up pressure and force as input.

Non-Layered Structural SOLID 186

20-Node Non-Layered Structural Solid (3-D SOLID186) element was suitable to be applied to the analysis, since it could take up pressure and force as input.

Geometry of SOLID 186

SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities.

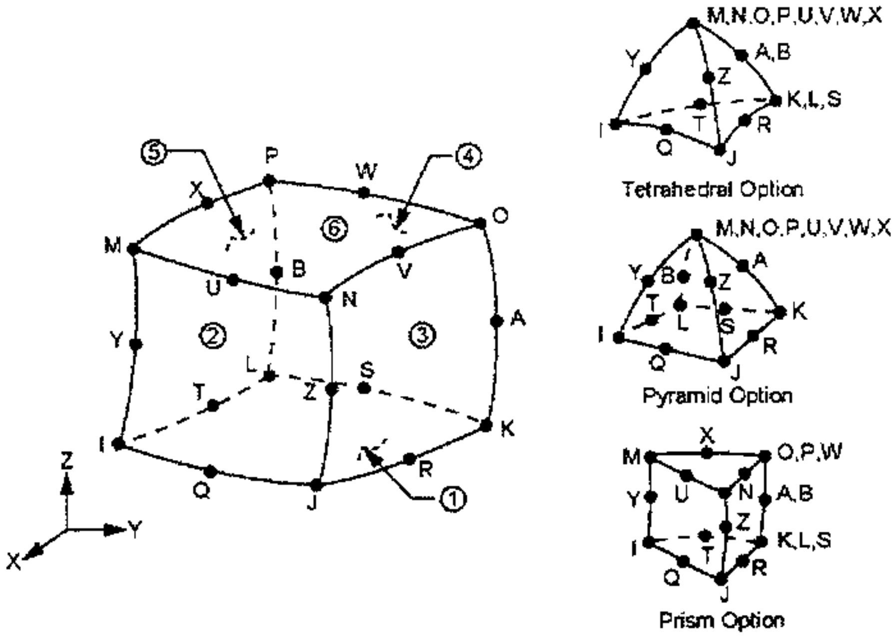

FIG 6.8 GEOMETRY OF SOLID 186

It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials.

Defining Material Properties

The Bolt is made with Light tempered Steel with the following properties. The steel grade used is steel C 60.

S. No.	Property	Value
1.	Ultimate tensile strength	750 N/mm^2
2.	Modulus of Elasticity	2.04 X 10^5 N/mm^2
3.	Poisson's ratio	0.3
4.	Yield Stress	420 N/mm^2

Table 6.2 Material Properties

6.3.2 Meshing the Model

The imported model is meshed wisely for the analysis. Mesh selection is very tedious process.

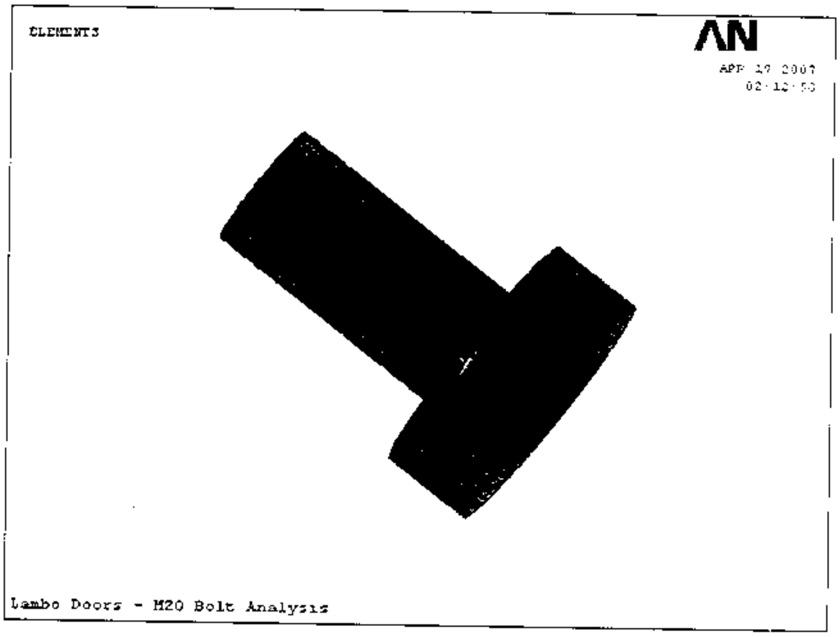

FIG 6.9 DISCRETIZED MODEL

In this case SWEEP mesh is selected and the imported model is meshed. Smart sizing gives the mesher a great opportunity to create reasonably shaped element during automatic element generation. In the mesh tool Smart sizing option is enabled and set at value 1. With that fine sizing the total no of elements and nodes what we got is mentioned below.

These are the major steps which we have to do in the pre-processing stage of this finite element analysis of the BOLT.

6.3.3 Load Calculation

In this section the exact load which will act on the BOLT at the time of opening of the door is listed down. The various components of force acting on the BOLT were calculated and explained individually. The pressure acting on the bolt is calculated below:

Weight of the door = 30 Kg.

Velocity with which the door swing open = 10 cm/s.

Diameter of the bolt stud = 5mm.

Length of bolt = 6mm.

So kinetic energy is given by,

Kinetic Energy = ½*weight*velocity^2.

K.E = ½*30*100^2.

K.E = 15*10^4 N-mm.

Angular distance swept = 949.2 mm.

Kinetic force = K.E/Distance Swept = (15*10^4)/949.2 =158 N.

Surface area of the bolt =2*3.14*Dia of bolt*length of bolt = 2*3.14*5*6.

Surface area of the bolt = 188.5 sq.mm.

Pressure acting on the bolt = Load/area = 158/188.5 = 0.84 N/mm^2.

6.3.4 Post Processing

Result Plots

After the solver completes the analysis it will calculate nodal and elemental results and will keep all the data ready for viewing. We can plot those data by selecting the following GUI path.

General Post Processing → Plot Results → Contour Plot → Nodal Solution.

A window will appear in which we can find various parameters. By selecting any of the required one, ANSYS will plot those results.

Displacement Plots

The displacement of the nodes created in the bolt because of load is plotted. The displacement in the X, Y, Z axes and the vector sum plot were shown below. All the results shown below belongs to the last sub step.

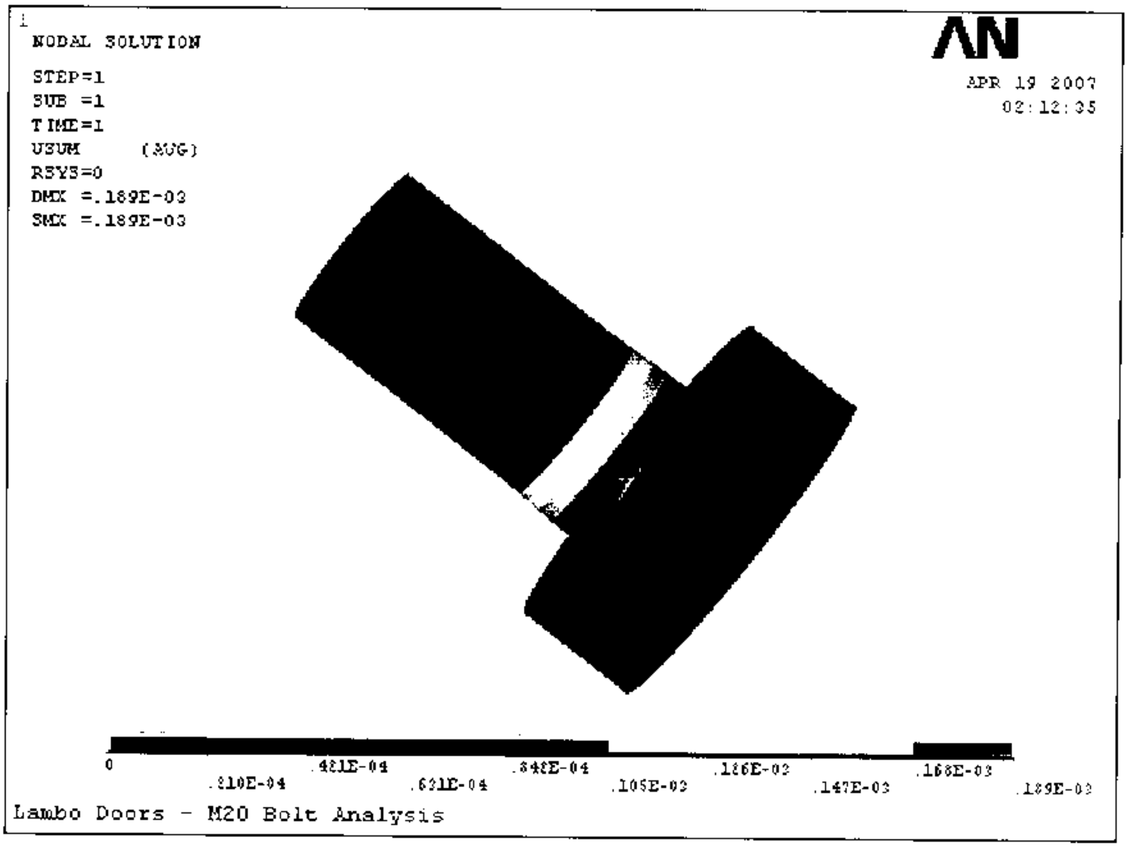

FIG 6.10 DISPLACEMENT VECTOR SUM

Stress Plots

Stress developed in the bolt in various axes because of load applied were plotted and shown below.

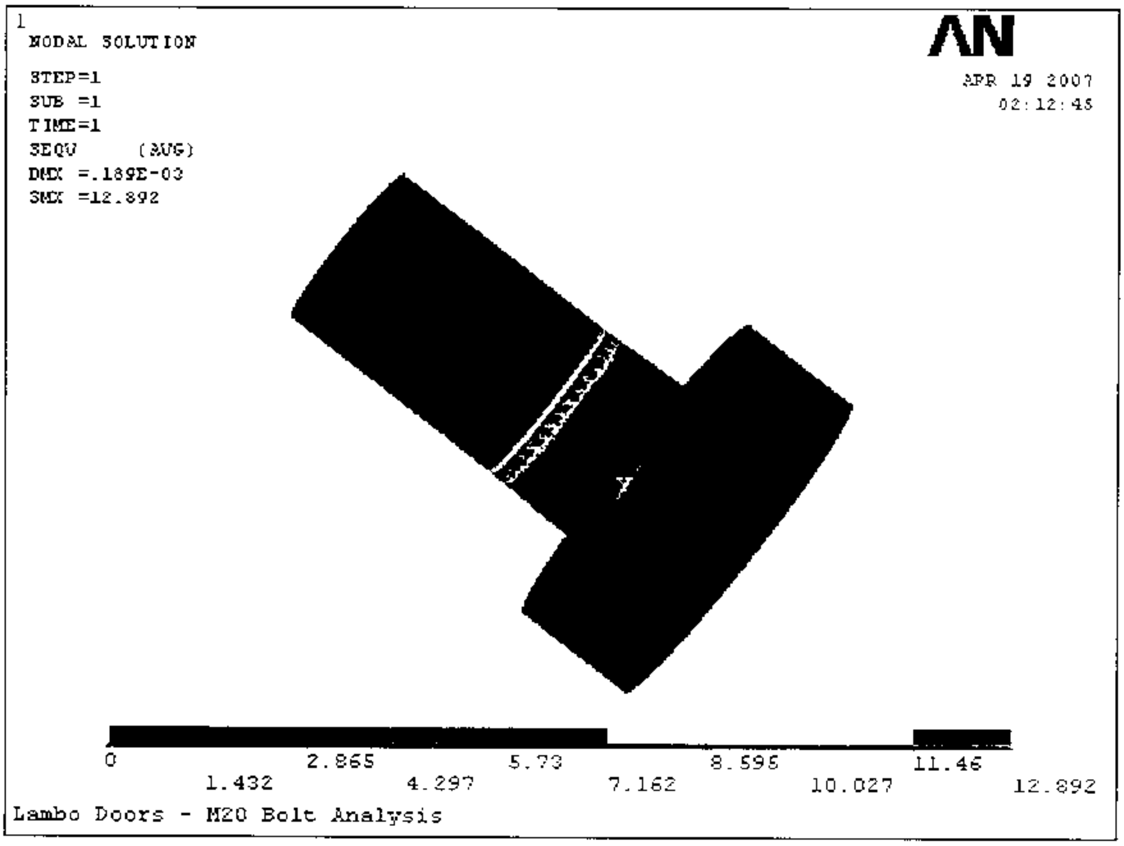

FIG 6.11 STRESS ANALYSIS

Thus the various result plots were shown above. It is seen from the data book that the yield strength of the bolt material is found to be 420 N/mm^2.The analysis made shows the stress value to be 12.892 N/mm^2.Since this stress is well below the yield strength of the bolt the design is safe.

CHAPTER 7

LIMITATIONS AND FUTURE WORKS

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7.1 LIMITATIONS:

One of the main objectives of this project is to change the ordinary stock door of the car into a scissor door with as little alterations as possible. The whole setup is made as a bolt on kit that could be changed back when needed. This imposed some serious restrictions in the design. The same holes of the stock door had to be used. This meant that the hinge should be designed to be bolted only on the same holes no matter where the centre of gravity of the hinge acts. Since the door frame could not be altered the mechanism used cannot include larger mechanism that would perform the operation with ease.

The door handles and knobs prevented the door from performing like a real lambo door. So the door had to be swung out a little before pushing the door upwards. This reduced the intended parking space advantage of the lambo door.

The design is not uniform for all the Indian cars. The hinge of each car needs to be analyzed and accordingly a design has to be come up with. For example the door of Maruti Zen performs more like a scissor door than an Accent on which the project was carried on.

Since the design is not uniform for all cars, every time these doors are to be installed in a new car loads of design calculations needs to be done. Also the material wastage will be high for all the new designs manufactured.

The success of the project depends on the reach of the project. But people are known to be very protective of their automobiles and it remains to be seen if they are willing to risk them for the aesthetics and functionality of the idea.

7.2 FUTURE WORKS

In the future the design could be further refined so as to increase the parking space advantage. This can only be achieved by removing the restrictions on this design. If the door was removed of everything that is not essential, the swinging angle can be further reduced.

Also after carrying out this design in a few varieties of cars a database of sorts could be developed to contain the design specifications of each specimen. The idea could stand as an example to think out of the box and tackle other similar problems in the same fashion.

CHAPTER 8
CONCLUSION

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The project addresses the issue of decreasing parking spaces differently which is justified as a logical method. Lambo doors exhibit the functionality and aesthetics that they intend to. Reproducing the same results under a set of constraints is not easy. The hinge mechanism used needs less amount of alteration work in the car and so the originality of the car is kept on. In this aspect the project has an additional advantage over the foreign companies which meddle with the structural stability of the car. There have been instances of altered scissor doors falling upon users causing serious injuries. This design however has been properly analyzed and found to be perfectly safe. The cost of manufacture of the mechanism also amounts to little when compared to the mechanisms done by foreign companies. The design is therefore found to be arguably the safest and simplest lambo door conversion mechanism.

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