Design and Fabrication of Economical Multi Utility Vehicle

A Project Report

Submitted by

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in partial fulfillment for the award of the degree
of

Bachelor of Engineering
in
Mechanical Engineering

DEPARTMENT OF MECHANICAL ENGINEERING
KUMARAGURU COLLEGE OF TECHNOLOGY
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APRIL– 2007

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BONAFIDE CERTIFICATE

Certified that this project report entitled **"Design and Fabrication of Economical Multi Utility Vehicle"** is the bonafide work of

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This is to certify that the following students,

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Final year B.E. Mechanical Engineering of **Kumaraguru College of Technology, Coimbatore-06** done their project titled "**Design and Fabrication of Economical Multi Utility Vehicle**" during **Dec'06** to **Mar'07**.They have completed the project successfully and it is useful for us.

Proprietor

ABSTRACT

Our project entitled "Design and fabrication of economical multi utility vehicle" has an objective to make cheaper material handling vehicle for Sri Jayalakshmi Industries, Coimbatore-62. Our vehicle should be designed in such a way of easy for fabrication, maintenance, safety, fuel economy, easy to handle and ergonomical. Since the existing utility vehicles are designed for large scale industries and large agricultural field. Usage of those vehicles in small scale industries and small agricultural land holders are costlier to them, so the design of vehicle suiting for small scale people would really beneficial to them, which could reduce their operating cost and increase their rate of work. The load carrying capacity for small scale industries is very less when compared to large scale people their requirements are converted into our objective as mentioned above. Requirements of the end user were clearly discussed to meet the requirements of the product, existing vehicle were also analyzed to know their advantage and disadvantages in detail and an alternative design was made and the best solution was found to meet the objectives. Best designs were analyzed and redesigned to meet the requirement. This design includes the considerations of available resources supporting for design analysis, fabrication, testing and cost consideration. As per the process planning and scheduling, tasks were elaborately defined and carried out. All the above activities are well documented. We conclude that our design would be one of the best results for small scale industrial and agricultural purposes.

ACKNOWLEDGEMENT

We thank the almighty for giving us the strength and good health from which we were able to complete the project successfully.

We are blessed to have our supervisor and mentor Dr.P.Palanisamy Ph.D., without whose guidance and help we would not have been able to complete the project successfully with such precision.

We are blessed to have Dr.N.Gunasekaran Ph.D., Head of the Mechanical Engineering Department who has been instrumental and encouraging by letting us to use the laboratory facilities.

We acknowledge the support given to us by our Principal Dr.Joseph.V.Thanikal, for providing all the amenities to do this project.

We thank Mr.K.Aruchamy, Proprietor of Sri Jayalakshmi Industries for giving us this project and valuable guidance.

We thank all our friends and well wishers for bearing with us all through the demanding times and helping us to complete our project.

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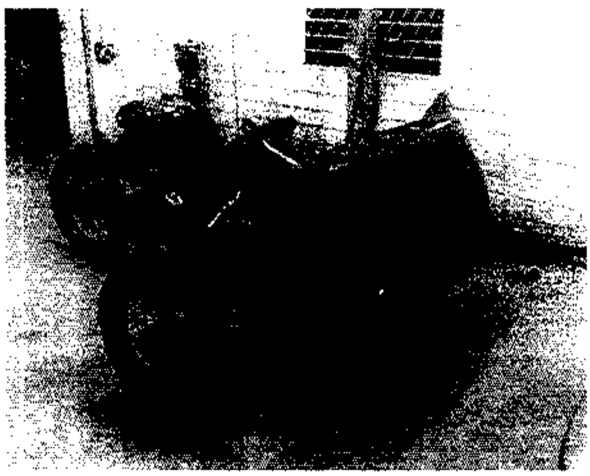
SYMBOL	MEANING	UNIT
V	Velocity	m/s.
W	Weight of the vehicle	kg.
A	Projected area	m^2.
η	Efficiency	-.
C_p	Specific heat capacity at constant pressure	kJ/kg K.
C_v	Specific heat capacity at constant volume	kJ/kg K.
γ	Ratio of specific heat capacities	-.
D	Diameter of the cylinder	m.
L	Stroke length	m.
N	Number of revolution of the crank shaft	rpm.
T	Torque developed	N-m.
P	Mean effective pressure	N/m^2.
Q	Heating value or calorific value of fuel	kcal/kg.
μ_b	Coefficient of friction between the brake lining and the drum.	m.
F_n	Normal force applied on the brake shoes	N.
R_b	Radius of the brake drum	m.



CHAPTER 1

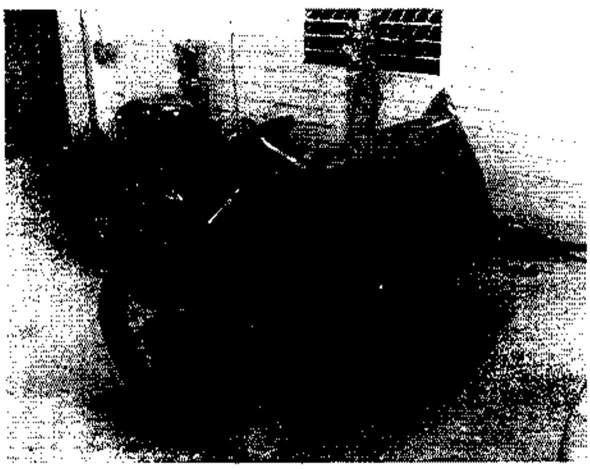
INTRODUCTION

1.1 IMPORTANCE OF THE PROJECT

There are many means of transportation for various fields like foundries, machine shops, textiles etc., companies are manufacturing many vehicles like lorry, van, tempo, tractors etc., in the form of three wheelers and four wheelers. Bajaj, Tata, Ashok Leyland, Mahindra are the names of some of the companies whose vehicles serves in these fields. Because of usage in various fields and road use the vehicle should face various norms of ARAI (Automotive Research Association of India). So the cost of manufacturing the vehicle is high. Manufacturing of vehicle for the usage (specific purpose) in small scale industries like SRI JAYALAKSHMI INDUSTRIES and for other similar industries would face only few or nil norms of ARAI so the vehicle could come at cheaper price. As the vehicle is designed for small industrial and agricultural people they could easily implement this, can operate at higher rate at low cost and could save money.

1.2 SCOPE OF THE PROJECT

As the vehicle is cheaper than the other existing vehicles in the market, purchasing capacity of people increases. As the operating cost like maintenance, fuel economy are cheaper, in a long run also they never face any difficulty in regular usage of the vehicle. The vehicle is more stable than other existing three wheelers could run in more difficult terrains than existing vehicle faced today. Most of the spares and components used are two wheeler parts and standard engine parts, a cheaper mechanic could well maintain it. Pollution can be controlled by using the jatroba oil. The vehicle has a trailer mounting so that transportation of materials is carried out easily. Since the vehicle is using a stationary single cylinder diesel engine this could be used for running pumps in agricultural field where the electric supply is not available. The vehicle is chain driven so the optimum capacity of generator could be coupled with this one and could easily generate electricity.



CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

The first three wheeler with two front and one rear wheel was first introduced by H.F.S.Morgan, the founder of the Morgan Motor Co., and the world famous Morgan three wheeler. He was born on 1881; Henry Frederick Stanley Morgan was educated at Stone House, Broadstairs, Marlborough and the Crystal Palace Engineering College. In 1900 he became a pupil of Mr. W. Dean, chief G.W.R. engineer at Swindon Works, and, after the usual course, he got a job in the works drawing office. His first model was built in 1909 using a 7 H.P. Peugeot engine.

From 1910-1952 the Morgan Motor Company sold a huge variety of different three-wheeler models. They all had in common the independent front-wheel-suspension, the arrangement of the engine in front and rear-wheel-drive. Some of his models were:

SPORTING (1919)

Built from 1913-1921.

The body of the Sporting was made without doors for strength, light weight, more speed and sporting appearance.

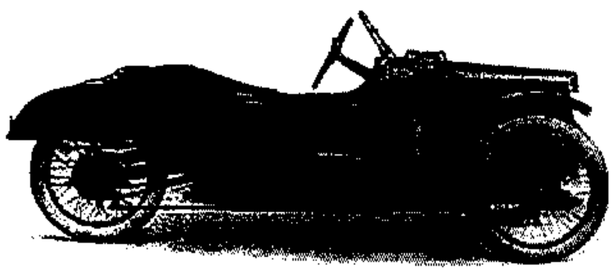


FIG 2.1 MORGAN'S SPORTING MODEL.

2.2 CURRENT CARS

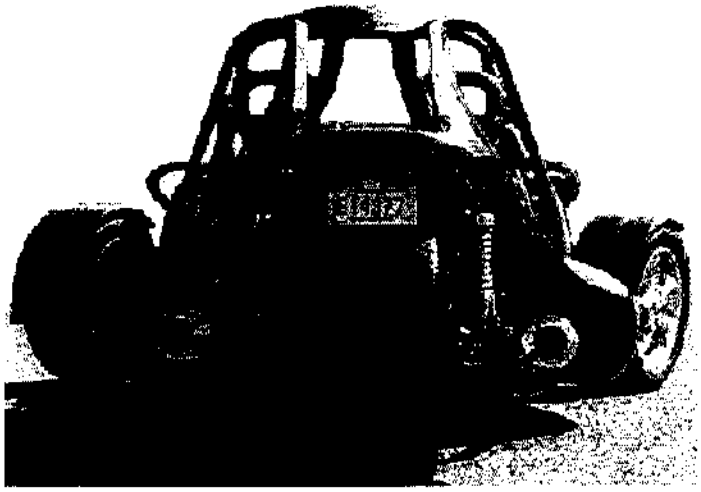
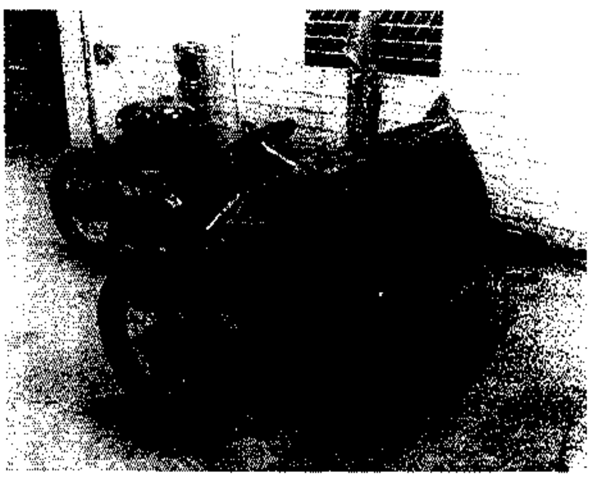


FIG 2.2 CURRENT THREE WHEEL CAR

The Morgan and the existing cars are meant only for road use only. Importing of such cars and modifying it for our purpose will be more expensive. These vehicles have the following disadvantages:

- Roll over stability at high speed cornering.
- Rear wheel spin for the rear mounted engines.

Since the speed of the vehicle inside the company is limited, the rolling effect is eliminated. Moreover mounting the trailer at the end of the vehicle eliminates the rear wheel spin. We employed two wheeler spares in this vehicle to make the system simple and easy repairability at low cost.



CHAPTER 3

DESIGN AND ANALYSIS

3.1 DESIGN PROCESS:

The design process is the pattern of activities that is followed by the designer in arriving at the solution of a technological problem. The design process is an iterative procedure, as shown in fig 3.1. A preliminary design is made based on the available information, and is improved upon as more and more information is generated. There have been several attempts to provide a formal description of the stages or elements of the design process. The design progresses in a step-by-step manner from some statement of need through identification of the problem, a search for solutions and development of the chosen solution to manufacture, test and use. These descriptions of design are often called models of design process.

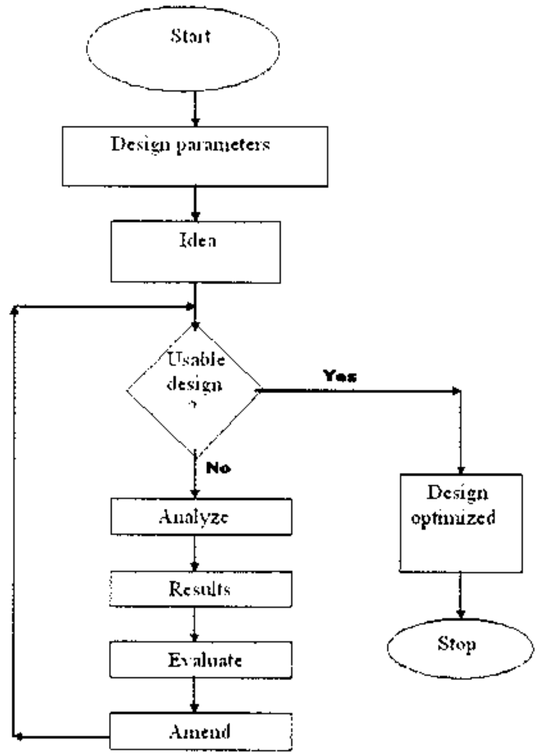


FIG 3.1 ITERATIVE DESIGN PROCEDURE

3.2 PRO-E DESIGN

The chassis design was made using Pro-E, modeling software and it is shown below:

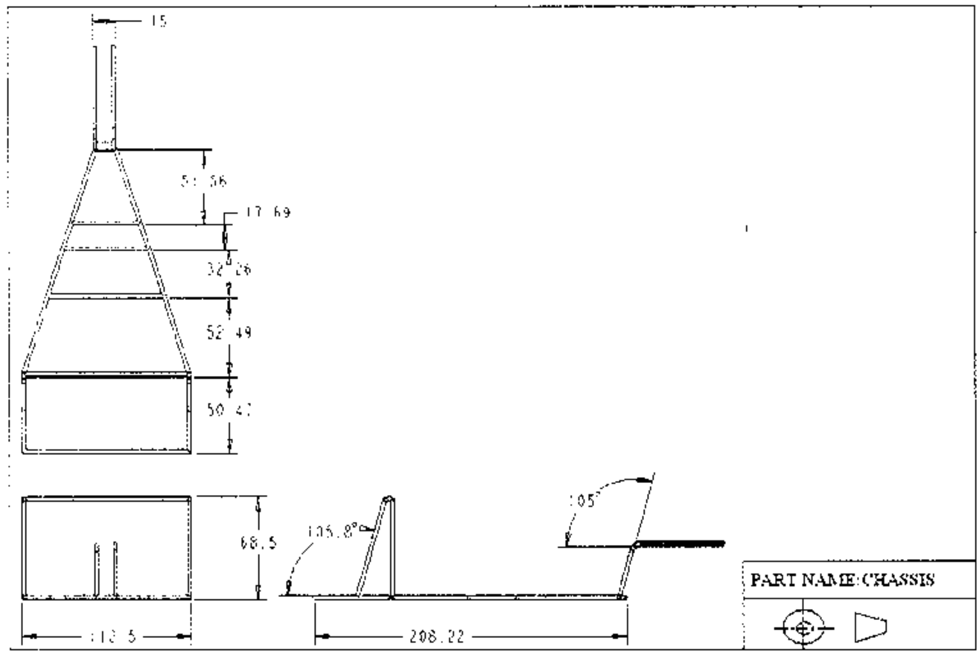


FIG 3.2 VARIOUS VIEWS OF CHASSIS

Once the design process was completed the next process was selecting an apt material for analysis.

3.3 MATERIAL SELECTION:

The objective of any practical work dealing with the manufacture of products is to produce components that will adequately perform their designated task. Meeting this objective implies the manufacture of components from selected engineering materials with the required geometrical shape and precision with the companion material structures that are optimized for the service environment that the component must withstand. The ideal design is one that will just meet all the requirements.

As a result of dynamic changes, the selection of engineering materials has become extremely important and the process now requires constant reevaluation. Concerns regarding environmental pollution, recycling and worker health and safety have imposed new constraints. New desires for weight reduction, energy saving, or improved corrosive resistance may well motive a change in engineering material. Finally, the proliferation of the product liability actions, many of which are the result of improper material use, has further emphasized the need for constant reevaluation of the engineering materials in the product.

3.4 PROCEDURE FOR MATERIAL SELECTION:

The selection of any appropriate material and its subsequent conversion into a useful product with desired shape and properties can be a rather complex process. Nearly every engineered item goes through the following sequence of activities:

- Design
- Material
- Process selection
- Production
- Evaluation
- Possible redesign and modification.

Numerous engineering decisions are made alone the way. Several methods have been developed for approaching a design and selection problem. The case-history method assumes that if something has worked successfully before, a similar component could be made with the same engineering material and method of manufacture. This, approach is quite useful, and many manufactures evaluate their competitor's product for just this purpose. Nevertheless, minor variations in service requirements may well require different materials or different manufacturing operations. Moreover this approach tends to preclude the use of new technology, new materials, and other manufacturing advances that have occurred since the formulation of the previous solution.

Other design and selection activities involve the modification of an existing product, generally in an effort to reduce cost or to improve quality. Efforts here can begin with an evaluation of the current product and its present method of manufacture.

The safest and most through method for design and selection is to approach the task as through it were the development of an entirely new product.

Here the full sequence of design, material selection, and process selection will be followed prior to production.

This first step in any material selection problem is to define the needs of the product. Without prior biases about material or method of fabrication, the engineer should develop a clear picture of all the characteristics necessary for this parts to adequately perform its intended function. These requirements will fall into three major areas:

- Shape or geometry considerations
- Property requirements
- Manufacturing concerns

Considering all the requirements the material chosen for frame chassis and other parts is mild steel.

3.5 THE CHASSIS CONSTRUCTION

The chassis of our vehicle consists of following components suitably mounted:

- Engine
- Transmission system, consisting of the clutch, gear box.
- Suspension system.
- Road wheels.
- Steering system.
- Brakes
- Fuel tank.

All the components listed above are mounted in either of the two ways, viz., the conventional construction, in which a separate frame is used and the frameless or unitary construction in which no separate frame is employed. Out of these, the conventional type of construction is used for our vehicle.

3.6 TYPES OF CHASSIS

Chassis are classified as:

Conventional control chassis, in which engine is mounted in front of the driver's cabin. This type of arrangement avoids full utilization of the space.
Semi –forward control chassis, in which engine is so mounted that half of it is in the driver's cabin whereas the other half is in front, outside the driver's cabin.
Full forward control chassis, in which engine is mounted completely inside the driver's cabin. Obviously maximum utilization of space is achieved in this type of arrangement.

3.7 CONVENTIONAL CONSTRUCTION

In this type of chassis construction the frame is the basic unit to which various components are attached and body is bolted on to the frame later on.

3.8 FUNCTIONS OF THE FRAME

1. To support the chassis components and the body.

2. To withstand static and dynamic loads without undue deflection or distortion.

3.9 LOADS ON THE FRAME

1. Weight of the vehicle and the passengers, which causes the vertical bending of the side members.

2. Vertical loads when the vehicle comes across a bump or hollow, which results in longitudinal torsion due to one wheel lifted (or lowered) with other wheels at the usual road level.

3. Loads due to road camber, side wind, cornering force while taking a turn, which result in lateral bending of side members.

4. Load due to wheel impact with road obstacles may cause that particular wheel to remain obstructed while the other wheel tends to move forward, distorting the frame to parallelogram shape.

5. Engine torque and braking torque tending to bend the side members in the vertical plane.

6. Sudden impact loads during collision, which may result in a general collapse.

3.10 MATERIALS FOR FRAME

Steels used for frame are mild steel, carbon steel and nickel alloy steel. Out of these materials we have chosen mild steel and the composition is as follows.

Carbon	0.15-0.20 percent
Manganese	0.40-6 percent
Silicon	0.7 percent maximum
Phosphorus	0.5 percent maximum
Sulphur	0.05 percent maximum

Mechanical properties

Young's modulus	200-500Mpa.
Yield strength	225 Mpa.
Elongation	20percent minimum on 100mm.

3.11 DEFECTS IN FRAME

The only prominent defect that usually occurs in the frames due to accidents is the alignment fault. This may be checked by means of a plumb line. The vehicle is placed on a level surface and by suspending plumb line from four different points on each side of the frame; their position on the ground is marked. The vehicle is then taken away and the diagonals are measured between corresponding points. These should not differ by more than 7 or 8 mm. if any of the corresponding diagonals do differ by more than this amount, the frame is out of alignment. The possible cause, then, may be any one of the following:

1. The dumb irons or side members may be bent.

2. Cross members may be buckled.

3. Some rivets may be loose or broken.

If the damage to the frame members is small, they can be repaired by means of a hydraulic jack and wringing irons. If the damage is more, the bent frame member may be heated to straighten it. Another alternative may be to cut the damaged part and weld a new one instead.

3.12 ANALYSIS

The analysis of chassis is carried out using ANSYS 8.0 version. Some of the input parameters are:

Material properties

Mild steel:

1. Young's modulus (E) $=2\times10^5 N/mm^2$.
2. Poisson's ratio (υ) = 0.3
3. Area $= \pi (D^2-d^2)/4 = 188.49 mm^2$.

   Where,

   Outer diameter of hollow pipe D=32mm.

   Inner diameter of hollow pipe d=28mm.
4. Moment of inertia $= \pi (D^4-d^4)/64 = 21299.9 mm^4$.
5. Type of mesh = line.
6. Type of element = 2D elastic beam.
7. Load applied = 210kg.

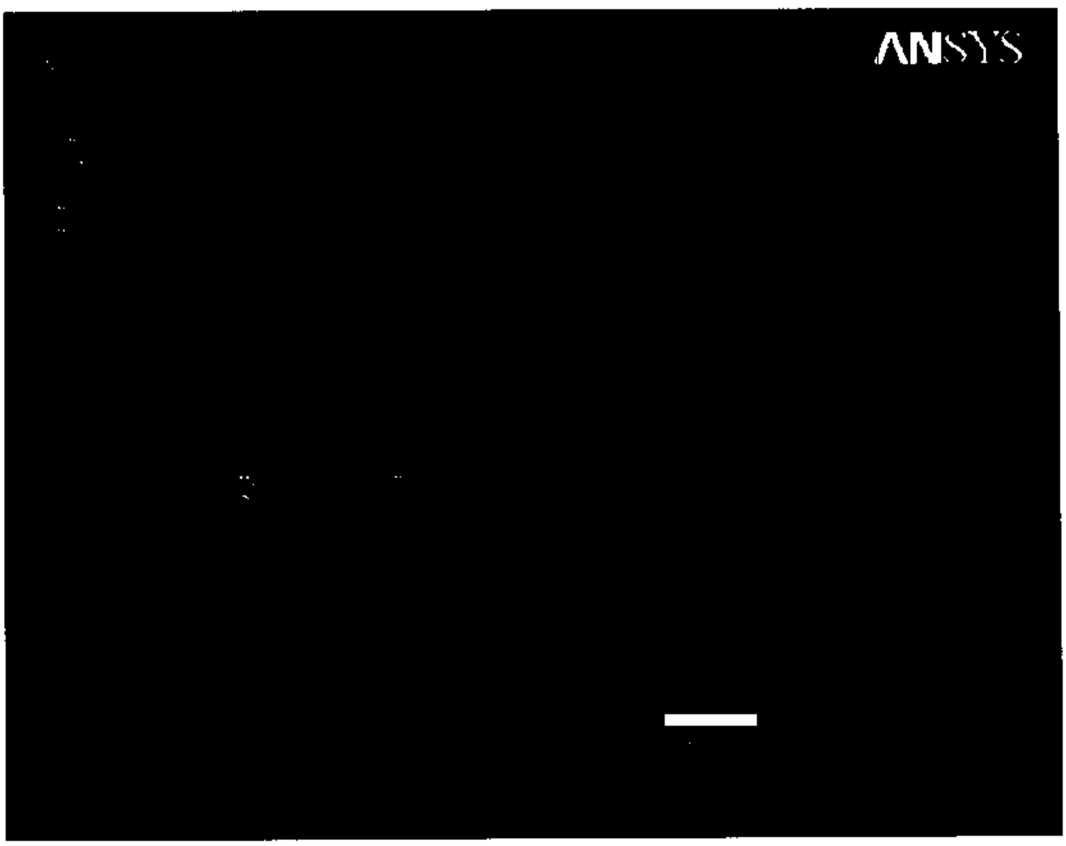


FIG 3.12 OBSERVATIONS FROM ANSYS

3.13 RESULTS FROM ANALYSIS

1. Maximum deflection along z-axis = 3.97 mm.
2. Stress developed = 209N/mm^2.

As the maximum deflection is less than 20% (as specified in 3.9) and the stress developed is also less than the yield stress the design is safe.

3.14 LOAD CALCULATIONS

For a vehicle moving on a level road, only the rolling and air resistance are encountered and no gradient resistance is encountered.

$$H.P = \frac{(16.9V+.032V^2)\,W+0.003212AV^3}{269.95}$$

Where.

W- Weight of the vehicle in tonnes.

V- Velocity in km.p.h.

A- Projected area in sq.metres.

=2.438m^2.

H.P=6.5.

From the previous formulae

1. Let V=30 km.p.h,

$6.5 = [16.9(30) + .032(30^2)]\ W+ (.003212x2.438x30^3)]\ /269.95$

W=2.88 tonnes.

2. Let V=40 km.p.h,

1754.675=727.2W+486.68

W=1.743 tonnes.

3. Let V=50 km.p.h,

1754.65=925W+978.24

W=0.8393 tonnes.

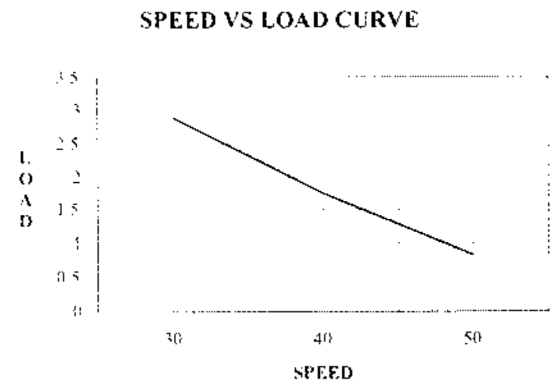


FIG 3.15 SPEED VS LOAD CURVE

From the graph we infer that as the load on the vehicle increases the speed decreases.

CHAPTER 4

STUDY AND SELECTION OF ENGINE

4.1 ENGINE

The moving power for moving the car wheels and other parts of automobile is provided by the engine or the power plant.

4.1.1 TYPES OF ENGINE

Internal combustion engines can be classified on any one of the following basis:

a) Type of fuel used:

1. Petrol or gasoline engine.
2. Diesel engine.
3. Gas engine.

b) Cycle of operation:

1. Otto cycle engine.
2. Diesel cycle engine.
3. Dual combustion cycle or semi-diesel engine.

c) Types of ignition used:

1. Spark ignition engine.
2. Hot-spot ignition engine.
3. compression ignition engine

d) Method of fuel admission:

1. Carburettor engine (petrol).
2. Air injection engine (diesel).

e) Number of strokes per cycle:

1. Four stroke engine.
2. Four stroke engine.

f) Arrangement of cylinder:

1. Vertical engine.
2. Horizontal engine.
3. Radial engine.
4. V-engine.
5. Opposed cylinder engine.

g) Valve location:

1. Overhead valve engine.
2. Side wall engine.

h) Type of cooling engine:

1. Air cool engine.
2. Water cool engine.

i) Lubrication systems:

1. Wet sump.
2. Dry sump.
3. Pressurized.

j) Speed:

1. Slow speed engine.
2. High speed engine.
3. Medium speed engine.

k) Method of governing:

1. Hit and miss governed engine.
2. Qualitatively governed engine.
3. Quantitatively governed engine.

l) Application:

1. Stationary engine.
2. Automotive engine.
3. Marine engine.
4. Locomotive engine.

Now let us look at the characteristic of diesel fuel and diesel engine (four stroke) since it is used in our project.

4.2 CHARACTERISTIC OF DIESEL FUEL

Diesel fuel is heavier and oilier. Diesel fuel evaporates much more slowly than gasoline -- its boiling point is actually higher than the boiling point of water. You will often hear diesel fuel referred to as "diesel oil" because it is so oily.

Diesel fuel evaporates more slowly because it is heavier. It contains more carbon atoms in longer chains than gasoline does (gasoline is typically C_9H_{20}, while diesel fuel is typically $C_{14}H_{30}$). It takes less refining to create diesel fuel, which is why it is generally cheaper than gasoline.

Diesel fuel has a higher energy density than gasoline. On average, 1 gallon (3.8 L) of diesel fuel contains approximately 155×10^6 joules (147,000 BTU), while 1 gallon of gasoline contains 132×10^6 joules (125,000 BTU). This, combined with the improved efficiency of diesel engines, explains why diesel engines get better mileage than equivalent gasoline engines.

4.3 DIESEL ENGINE

Rudolf Diesel developed the idea for the diesel engine and obtained the German patent for it in 1892. His goal was to create an engine with high efficiency. Gasoline engines had been invented in 1876 and, especially at that time, were not very efficient.

Note that the diesel engine has no spark plug, that it intakes air and compresses it, and that it then injects the fuel directly into the combustion chamber (direct injection). It is the heat of the compressed air that lights the fuel in a diesel engine.

4.4 BASIC ENGINE PARTS

Let us look at some of the engine components in detail:

a) Cylinder

A cylinder in an internal combustion engine is the main part in which combustion takes place. The cylinder has to withstand high temperatures and high pressures.

b) Piston

A piston is a cylindrical piece of metal that moves up and down inside the cylinder.

- It receives the thrust produced by combustion and transmits the power to the connecting rod.
- It reciprocates to cause different strokes.
- It acts as bearing to the small end of the connecting rod and bears side thrust.

c) Piston Rings

Piston rings provide a sliding seal between the outer edge of the piston and the inner edge of the cylinder. The rings serve four purposes:

- They prevent the fuel/air mixture and exhaust in the combustion chamber from leaking into the sump during compression and combustion.
- They keep oil in the sump from leaking into the combustion area, where it would be burned and lost.

Most cars that "burn oil" and have to have a quart added every 1,000 miles are burning it because the engine is old and the rings no longer seal things properly.

d) Connecting Rod

The connecting rod connects the piston to the crankshaft. It can rotate at both ends so that its angle can change as the piston moves and the crankshaft rotates.

e) Crankshaft

The crankshaft turns the piston's up and down motion into circular motion just like a crank on a jack-in-the-box does.

f) Sump

The sump surrounds the crankshaft. It contains some amount of oil, which collects in the bottom of the sump (the oil pan).

4.5 FOUR STROKE CYCLE

The four-stroke engine article also explains that the gasoline engine cycle, where gas and air are mixed and compressed together, is not really a perfect match for the four-stroke approach. The problem is that some unburned fuel leaks out each time the cylinder is recharged with the air-fuel mixture.

It turns out that the diesel approach, which compresses only air and then injects the fuel directly into the compressed air, is a much better match with the four-stroke cycle. Many manufacturers of large diesel engines therefore use this approach to create high-power engines.

The figure below shows the layout of a typical four-stroke diesel engine:

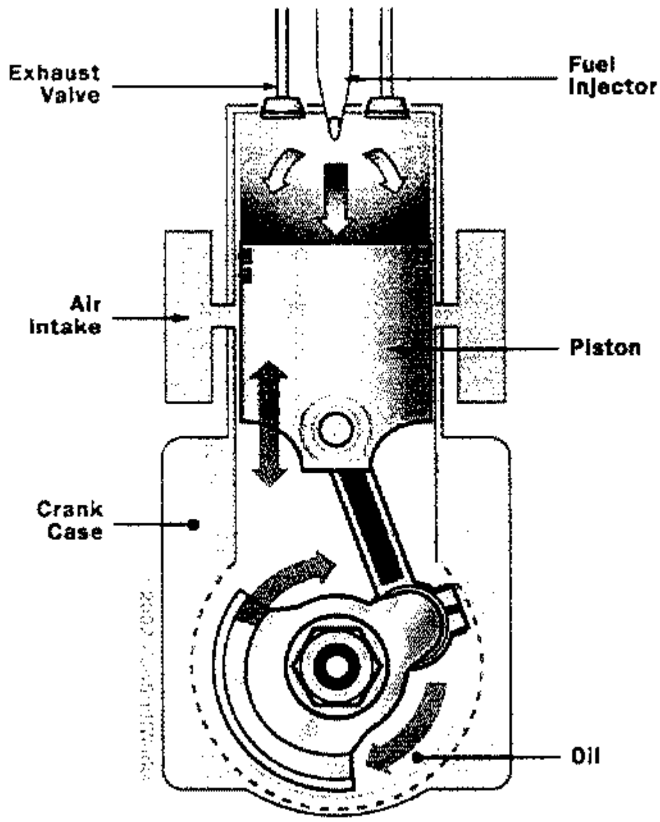


FIG 4.5 FOUR STROKE DIESEL ENGINE

At the top of the cylinder are typically two or four exhaust valves that all open at the same time. There is also the diesel fuel injector. The piston is elongated, as in a gasoline four-stroke engine, so that it can act as the intake valve. At the bottom of the piston's travel, the piston uncovers the ports for air intake. The intake air is pressurized by a turbocharger or a supercharger .The crankcase is sealed and contains oil as in a four-stroke engine.

The four-stroke diesel cycle goes like this:

1. When the piston is at the top of its travel, the cylinder contains a charge of highly compressed air. Diesel fuel is sprayed into the cylinder by the injector and immediately ignites because of the heat and pressure inside the cylinder.
2. The pressure created by the combustion of the fuel drives the piston downward. This is the power stroke.

3. As the piston nears the bottom of its stroke, all of the exhaust valves open. Exhaust gases rush out of the cylinder, relieving the pressure.
4. As the piston bottoms out, it uncovers the air intake ports. Pressurized air fills the cylinder, forcing out the remainder of the exhaust gases.
5. The exhaust valves close and the piston starts traveling back upward, re-covering the intake ports and compressing the fresh charge of air. This is the compression stroke.
6. As the piston nears the top of the cylinder, the cycle repeats with step 1.

4.6 AIR STANDARD EFFICIENCY OF A DIESEL CYCLE

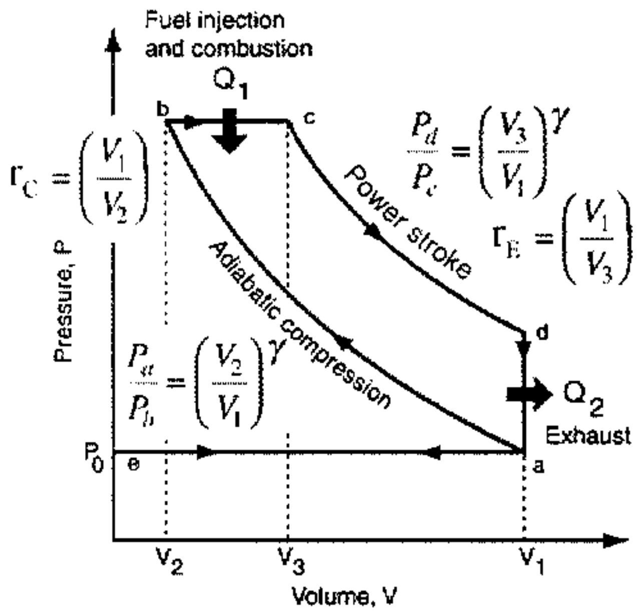


FIG 4.6. AIR STANDARD DIESEL ENGINE CYCLE

In the diesel engine, air is compressed adiabatically with a compression ratio typically between 15 and 20. This compression raises the temperature to the ignition temperature of the fuel mixture which is formed by injecting fuel once the air is compressed.

The ideal air-standard cycle is modeled as a reversible adiabatic compression followed by a constant pressure combustion process, then an adiabatic expansion as a power stroke and an isovolumetric exhaust. A new air charge is taken in at the end of the exhaust, as indicated by the processes a-e-a on the diagram.

Since the compression and power strokes of this idealized cycle are adiabatic, the efficiency can be calculated from the constant pressure and constant volume processes. The input and output energies and the efficiency can be calculated from the temperatures and specific heats:

$Q_1 = C_P(Tc\text{-}Tb)$

$Q_2 = C_v(T_a\text{-}T_d)$

Efficiency = $\eta = (Q_1 + Q_2)/ Q_1$.

It is convenient to express this efficiency in terms of the compression ratio $r_C = V_1/V_2$ and the expansion ratio $r_E = V_1/V_3$. The efficiency can be written

$\eta = 1+(Q_2/ Q_1) = 1+[C_v(T_a\text{-}T_d)/ C_P(T_c\text{-}T_b)]$.

and this can be rearranged to the form

$\eta = 1\text{-}(r_E^{-\gamma} - r_C^{-\gamma})/ \gamma\ (r_E^{-1} - r_C^{-1})$.

For an air standard engine with $\gamma = 1.4$, compression ratio $r_C = 15$ and expansion ratio $r_E = 5$, this gives an ideal diesel efficiency of 56%. The diesel cycle depends upon this temperature being high enough to ignite the fuel when it is injected.

4.7 TERMINOLOGIES

a) Horse Power

A horse power (h.p.) is the power of one horse, or a measure of the rate at which a horse can work. A 10 h.p. engine, for example can do the work of 10 horses.

A horse power is 75 m-kg/sec or 4500 m-kg/min. As illustrated, the horse walks 50m in one minute, lifting the 90kg weight. The amount of work done is 50×90 =4500 is m-kg/min.

Horse power is bigger unit of power. Power is generally expressed in horse power.

1 horse power = 75 m-kg/sec

= 4500 m-kg/min

b) Torque

Torque is the twisting or turning effect. The torque is equal to the product of the force and its perpendicular distance to the point of rotation. It may or may not result in motion. Power is something else again. It is the rate at which work is being done, and this means that something must be moving.

c) Bore And Stroke

The inside diameter of the cylinder is called is called is called bore. Stroke is the distance the piston travels from bottom dead centre to top dead centre. The size of an engine cylinder is referred to in terms of the bore stroke. These measurements are used to calculate the piston displacement. There are several reasons for having smaller stroke:

1. Less friction loss:
2. Reduced inertia and centrifugal loads on the engine bearing.
3. Reduced engine height and lower hood line

d) Piston Displacement

Piston is the volume displaced by the piston as it moves from its top dead centre to bottom dead centre position. It determines the size of the piston in cubic centimeters. This volume depends on the cylinder bore and the piston stroke.

e) Engine Displacement

Engine displacement has been defined as the total volume displaced by all the pistons as they move from their top dead centre to bottom dead centre position. It determines the size of an engine in cubic centimeters (cc). This volume depends on the cylinder diameter (bore), piston stroke and the number of the cylinder. Thus

$$\text{Engine displacement} = \pi D^2/4 \times L \times n \text{ cc}$$

Where D=diameter of cylinder in cm

L=length of stroke in cm

n=No. of cylinder.

f) Compression Ratio

It is the ratio of volume of the charge in the cylinder above the piston at bottom dead centre and the volume of the when the piston is at top dead centre. Since the volume above the piston at bottom dead centre is the displacement of the cylinder plus the clearance volume and the volume above the piston at the top dead centre is the clearance volume, the compression ratio can be stated as

(Clearance volume + displacement volume)/ Clearance volume

The compression ratio of an engine will be increased by any condition that will decrease the size of the clearance volume such as the accumulation of the carbon deposits. High compression ratio results in decreased operating efficiency and greater horse power output for a given engine.

The pressure of the mixture at maximum compression ratio. Some other factors are also considered like engine speed and temperature; degree of the fuel, leakage past the piston rings and waves.

g) Volumetric Efficiency

The volume of air- fuel mixture drawn into the cylinder at atmospheric pressure during the intake stroke compared to the volume of the cylinder is known as the volumetric efficiency.

The factors determining the volumetric efficiency are manifold and carburettor design, value timing, throttle opening etc. The higher the volumetric efficiency the more power the piston will develop when the mixture is burned.

Volumetric efficiency can be improved by making intake values larger. Also, the larger and straight intake-manifold passages will improve the volumetric efficiency. Carburetors are often equipped with extra circus or air passages which open at high speeds to improve engine breathing which ultimately increases the volumetric efficiency.

h) Engine Rating

All types of engines are rated in horse power –the measure of the rate at which they can do work. It has been already stated that one horse power equals to 75 m-kg/sec or 4500 –kg/min.

The engine power can be increased in four ways:

1. The power developed by the expansion of gases in the cylinder can be determined, as by indicator cards, in which case indicated horse power (I.H.P.) is obtained.
2. The power which the engine actually delivers can be measured by some measuring instruments like pony brake or dry-manometer-in which case break horse power (B.H.P.) is obtained.

i) Indicated Horse Power (I.H.P.)

The power actually develop inside the engine cylinder by the combustion of fuel is called indicated horse power. It is given by the relation.

I.H.P.=PLAN/4500 for2- stroke engine

=PLAN/2/4500 for 4- stroke engine

Where P=mean effective pressure in kg/cm^2 absolute.

L=length of stoke in meter.

A=area of cross section of the piston in cm^2.

N=number of revolution of the crankshaft.

(In 2-stroke engine, no. of explosions = no. of r.p.m of the crankshaft)

(In 4-stroke engine, no. of explosions 1/2×no. r.p.m. of the crankshaft)

This is the power developed by a single cylinder engine. If there is multi cylinder engine, this amount should be multiplied by the number of cylinders to get the total indicated horse power of the engine.

j) Brake Horse Power (B.H.P.)

The power which the engine actually delivers to do the outside work is called brake horse power. It is the output power of an engine. It is usually 70 to 85% of its indicated horse power. It can be measured by some measuring instruments like pony brake or dynamometer, and is given by the following relation:

$$B.H.P. = 2\pi NR\,(W-S)/4500$$
$$= \pi DN\,(W-S)/4500$$

Where, D=diameter of the brake drum =2R, in meters.

N=no. of revolutions/min of the crankshaft

W=load on the brake, in kg.

S=spring balance reading, in kg.

k) Frictional Horse Power (F.H.P.)

Output power (or B.H.P.) of an engine is always less than the input power (or I.H.P.), because some power is last in over coming the friction between the moving parts. The lost in the friction in the engine mechanism is called frictional horse power. It is equal to the difference between the I.H.P. and B.H.P. thus,

F.H.P. = I.H.P. - B.H.P.

In an automobile engine, the power is lost in:

(1) Friction between the cylinder wall and piston rings, bearings valve mechanisms.

(2) Charging work absorbed during the exhaust and suction strokes.

(3) Resistance of air to flywheel rotation.

(4) In running the auxiliaries- fuel pump, governor, lubricating oil, pump, water circulation pump, etc.

Frictional horse power can be determined by driving the engine with an electric motor to measure the horse power to measure the horse power required to drive it. During the test, the engine is at operating temperature, but there is no fuel in the carburetor, and the throttle is held wide open. It is seen that at low speed, the friction is relatively low, but as engine speed increases, it goes up rapidly.

4.8 ENGINE EFFICIENCIES

The term efficiency means the relationship between the effort exerted and the results obtained. Engine efficiency, the efficiency as applied to engine, is the relationship between the power delivered and the power obtained.

1. **Mechanical Efficiency** is the ratio of brake horse power to indicated horse power.

Mechanical efficiency = B.H.P./I.H.P.

Mechanical efficiency of an engine varies with the load. For ideal running with no shaft output, the indicated horse power is same as frictional horse power, or it can be expressed as

Mechanical efficiency = B.H.P. / (B.H.P. +F.H.P).

This assumes that all the variables affecting F.H.P. are constant. Thus, more real value of mechanical efficiency is obtained from the test of B.H.P. and I.H.P.

The factors affecting the mechanical efficiency of an engine are:

- Engine design.
- Speed.
- Cooling conditions.
- Quality and quantity of lubrication.
- Fitting and alignment of various parts.
- Manufacturing accuracy.

2. **Thermal Efficiency**. It is the ratio of B.H.P. or I.H.P. to that heat energy of the fuel supplied during the same interval of time.

Efficiency based on B.H.P. is called brake thermal efficiency, and is given by

$$\text{Brake thermal } \nu = \text{B.H.P.} \times 4500 / W \times Q \times J$$

Brake thermal efficiency is also called Overall efficiency.

Efficiency based on I.H.P. is called indicated thermal efficiency and is given by

$$\text{Indicated thermal} \eta = \text{I.H.P.} \times 4500 / W \times Q \times J$$

Where, W = weight of the fuel supplied in kg/min

Q = heating value or calorific value of fuel in kcal/kg

J = mechanical equivalent of heat=427

From it is clear that,

Mechanical efficiency = brake thermal efficiency/indicated thermal efficiency.

Because there is a great deal of heat lost during engine operation, thermal efficiencies of the engine may be as low as20% and are seldom higher than 25%.

3. **Relative Efficiency**. It is the ratio of indicated thermal efficiency. Thus,

$$\text{Relative } \eta = \text{Indicated thermal } \eta / \text{air standard } \eta$$

Where air standard efficiency = $1-1/(r^{\gamma-1})$.

$\gamma=C_p/C_v$

=Compression ratio.

4. **Scavenge efficiency**. For four-stroke engines, the concept of volumetric efficiency does not apply. Here another term called scavenge efficiency is used. It is measure of the extent to which burnt gases are removed from the cylinder, and the cylinder filled with fresh air charge. Thus,

$$\text{Scavenge } \eta = W_a/(V+V_c)\omega$$

Where, W_a = Weight of air charge retained in the cylinder in kg.

V= displacement volume in m^3.

V_c= clearance volume in m^3.

ω= specific weight of air charge in kg/m^3 at standard conditions of pressure and temperature.

TABLE 4.9

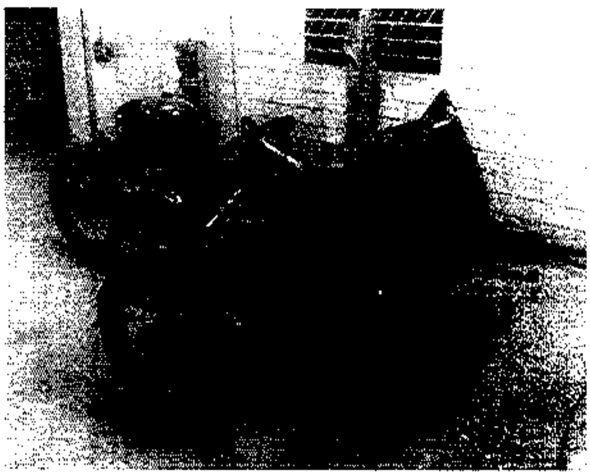
ENGINE SPECIFICATION

S.NO	DESCRIPTION	DETAILS
1	Manufacturer	Greaves Cotton
2	Series	500
3	Model no	4325
4	Bore	Φ78mm
5	Stroke	68mm
6	Total displacement	325cc
7	Compression ratio	18:1
8	Oil sump capacity	1litre
9	Lubrication oil	0.013kg/hr
10	Dry weight	38kg
11	Torque	1.48kg-m
12	RPM	3600
13	HP	6.5
14	Gear pump	Forced lubrication

15	Governor	Centrifugal
16	Lube oil filter	Full flow
17	Air filter	Oil bath

Other features

1. Automatic extra fuel device ensure easy engine starting.
2. Adequate capacity flywheel mounted fan ensures efficient cooling even at high ambient temperature.
3. Decompression lever remote throttle and stop.
4. Standard rotation of engine in anti clockwise direction.
5. Intermittent duty at variable speed and variable load.



CHAPTER 5

VARIOUS SYSTEMS OF THE VEHICLE

5.1 TRANSMISSION

The word 'transmission' means the whole of the mechanism that transmits the power from the engine crankshaft to the rear wheels. However the 'transmission' is also being used very commonly in the literature for a mechanism which provides us with suitable variation of the engine torque at the road wheels, whenever required. This may be a gear box or an automatic transmission. It is in this sense that the word 'transmission' is used in this chapter.

5.1.1 FUNCTIONS OF TRANSMISSION:

The main functions which are performed by the transmission are:

1. The torque or the tractive effort produced by the engine varies with speed only with speed only within narrow limits. But the practical considerations for the running of automobile under different conditions demand a large variation of torque available at the wheels. The main purpose of the transmission is to provide a means to vary the leverage or torque ratio between the engine and the road wheels as required.

2. The transmission also provides a neutral position so that the engine and the road wheels are disconnected even with the clutch in the engaged position.

3. A means to back the car by reversing the direction of rotation of the drive is also provided by the transmission.

5.1.2 NECESSITY OF TRANSMISSION:

The question as to how far is the transmission necessary in a vehicle may be answered by considering:

a) Variation of resistance to the vehicle motion at various speeds.

b) Variation of tractive effort of the available at various speeds.

5.1.3 TOTAL RESISTANCE TO VEHICLE MOTION:

It consists of:

(1) **Resistance due to wind**- This is taken to proportional to the square of vehicle speed.

(2) **Resistance due to gradient**- This remains constant at all speeds. This is the component of the vehicle weight parallel to the plane of the road.

(3) **Miscellaneous**- Apart from the above two types, various other factors also contribute towards the vehicle resistance. These are: type of road, tyre friction, etc. This may also be taken approximately to remain constant with the speed.

The total resistance for a particular type of road, therefore, may be represented as shown in the fig

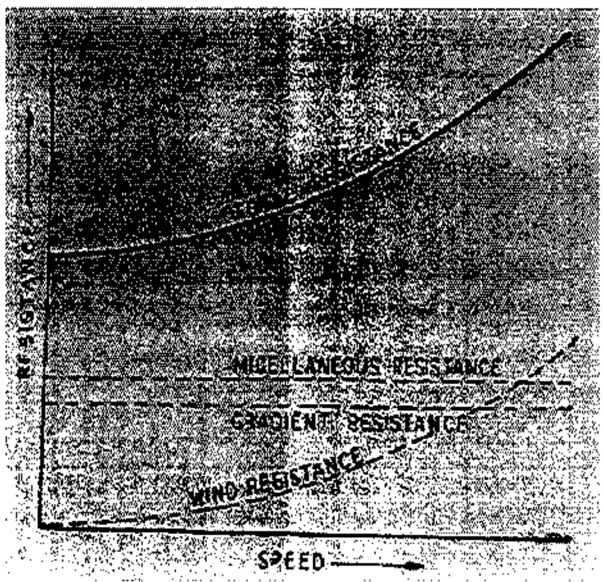


FIG 5.1.3 SPEED VS RESISTANCE CURVE

5.1.4 TYPES OF TRANSMISSION

The transmissions may be classified into

a) The manual types,

b) The automatic types.

   i. Semi-automatic one.

   ii. Fully- automatic one.

The manual transmissions are conventionally called gearboxes. Their mechanical efficiency in direct drive is about 98%, whereas in reduction gears, it is slightly greater than 90%. As most of the time the driving is done in direct drive, friction losses in manual transmissions are very small. That coupled with simplicity and lower initial cost, is the reason these are still popular in fuel-efficient automobiles. On the other hand of operation of engaging and disengaging the clutch along with changing of gears while driving over crowded highway means a lot of fatigue to the driver.

Therefore, in luxury vehicles automatic transmissions are employed which simplify the driving operation considerably. In semi-automatic type the clutch is operated automatically, the driver still has to select the gears. In the later type which is employed in modern cars, even the gears are changed automatically by a control mechanism which is actuated by the accelerator pedal only. In the fully automatic transmission, there are only two pedals, viz. for braking and for accelerating. In addition there is a selector lever.

5.1.5 TYPES OF GEARBOXES

There are four types of gear boxes:

a) Crash mesh or sliding mesh gear box.

b) Constant mesh gear box.

c) Synchro mesh gear box.

d) Planetary gearbox.

5.1.5. a CONSTANT MESH GEAR BOX

1. I speed gear
2. II speed gear
3. main shaft
4. III speed gear
5. top and III speed engaging dogs
6. top gear
7. primary shaft or main drive gear
8. counter shaft/cluster gear

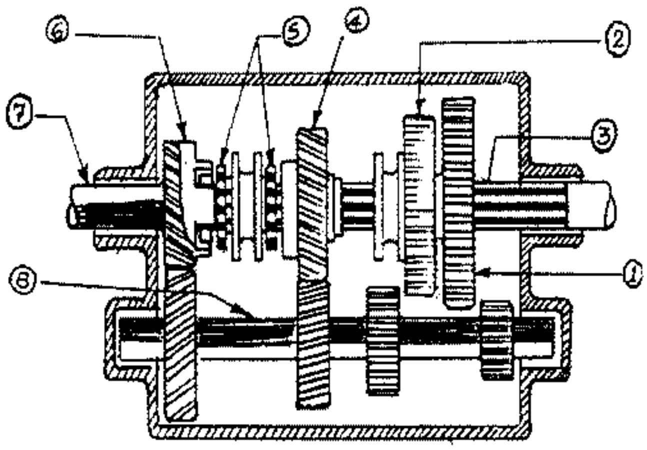


FIG 5.1.5.a CONSTANT MESH GEAR BOX.

In this type of gear box, all the gears are in constant mesh with the corresponding gears on the lay shaft. The gears on the main shaft which is splined are free. The dog clutches are provided which are free to slide on the main shaft. The gears on the lay shaft are, however, fixed.

When the left dog clutch is slid to the left by means of the selector mechanism, its teeth are engaged with those on the clutch gear end we get the direct gear. The same dog clutch, however, when slid to right makes contact with the second gear and second gear is obtained. Similarly movement of the right dog clutch to the left results in low gear and towards right in reverse gear.

5.1.5. b DOUBLE DECLUTCHING

In the constant mesh box, for the smooth engagement of the dog clutches it is necessary that the speed of main shaft gear and the sliding dog must be equal. Therefore to obtain lower gear, the speed of the clutch shaft, lay shaft and main shaft gear must be increased. This is done by double declutching. The procedure for double declutching is as given below:

The clutch is disengaged and the gear is brought to neutral. Then the clutch is engaged and accelerator pedal pressed to increase the speed of the main shaft gears. After this the clutch is again disengaged and the gear moved to the required lower gear and the clutch is again engaged. As the clutch is disengaged twice in this process, it is called double declutching.

For changing to higher gear, however, reverse effect is desired i.e., the driver has to wait with the gear in neutral till the main shaft speed is decreased sufficiently for a smooth engagement of the gear.

5.1.6 ADVANTAGE OF MANUAL TRANSMISSION

Manual transmissions typically offer better fuel economy than automatics. Increased fuel economy with a properly operated manual transmission vehicle versus an equivalent automatic transmission vehicle can range from 5% to about 15% depending on driving conditions and style of driving -- extra urban or urban (highway or city). There are several reasons for this:

1. Mechanical efficiency. The manual transmission couples the engine to the transmission with a rigid clutch instead of a torque converter that introduces significant power losses. The automatic transmission also suffers parasitic losses by driving the high pressure hydraulic pumps required for its operation.

2. Driver control. Certain fuel-saving modes of operation simply do not occur in an automatic transmission vehicle, but are accessible to the manual transmission driver. For example, the manual-transmission vehicle can be accelerated gently, yet with a fully open throttle (accelerator pedal to the floor), by means of shifting early to a higher gear, keeping the engine RPM in a low power band. By contrast, in an automatic transmission, the throttle position serves as the indicator of how fast the driver wishes to accelerate. If the accelerator pedal is floored, the transmission will shift to a lower gear, resulting in high engine RPM and aggressive acceleration. The thermodynamically efficient combination of open throttle and low RPMs is unavailable to the automatic transmission driver. Fuel-efficient acceleration is important to achieving fuel economy in stop-and-go city driving.

3. Fuel cut-off. The torque converter of the automatic transmission is designed for transmitting power from the engine to the wheels. Its ability to transmit power in the reverse direction is limited. During deceleration, if the torque converter's rotation drops beneath its stall speed, the momentum of the car can no longer turn the engine, requiring the engine to be idled. By contrast, a manual transmission, with the clutch engaged, can use the car's momentum to keep the engine turning, in principle, all the way down to zero RPM. This means that there are better opportunities, in a manual car, for the electronic control unit (ECU) to impose deceleration fuel cut-off (DFCO), a fuel-saving mode whereby the fuel injectors are turned off if the throttle is closed (foot off the accelerator pedal) and the engine is being driven by the momentum of the vehicle. Automatics further reduce opportunities for DFCO by shifting to a higher gear when the accelerator pedal is released, causing the RPM to drop.

4. Gear train efficiency. Automatics may require power to be transmitted through multiple planetary gear sets before attaining the desired gear ratio. In comparison, manual transmissions usually transmit power through one or two gear sets at most.

5. The heat issue can be important in certain situations, like climbing long hills in hot weather, particularly if pulling a load. Unless the automatic's torque converter is locked up (which typically only happens in an overdrive gear that would not be engaged when going up a hill) the transmission can overheat. A manual transmission's clutch only generates heat when it slips, which does not happen unless the driver is riding the clutch pedal.

A driver has more direct control over the state of the transmission with a manual than an automatic. This control is important to an experienced, knowledgeable driver who knows the correct procedure for executing a driving maneuver, and wants the machine to realize his or her intentions exactly and instantly. Manual transmissions are particularly advantageous for performance driving or driving on steep and winding roads. Note that this advantage applies equally to manual-automatic transmissions, such as tiptronic.

> An example: the driver, anticipating a turn, can downshift to the appropriate gear while the steering is still straight, and stay in gear through the turn. This is the correct, safe way to execute a turn. An unanticipated change of gear during a sharp turn can cause skidding if the road is slippery.

Driving a manual requires more involvement from the driver, thereby discouraging some dangerous practices. The manual selection of gears requires the driver to monitor the road and traffic situation, anticipate events and plan a few steps ahead. If the driver's mind wanders from the driving task, the machine will soon end up in an incorrect gear, which will be obvious from excessive or insufficient engine RPM. Related points:

- It's much more difficult for the driver to fidget in a manual transmission car, for instance by eating, drinking beverages, or talking on a cellular phone without a headset. During gear shifts, two hands are required. One stays on the wheel, and the other operates the gear lever. The hand on the wheel is absolutely required during turns, and tight turns are accompanied by gear changes. If the hand leaves the wheel, the steering will begin to straighten. In general, the more demanding the driving situation, the more difficult it is for the manual driver to do anything but operate the vehicle. The driver of an automatic transmission can engage in distracting activities in any situation, such as sharp turns through intersections or stop-and-go traffic.

- Cars with manual transmissions can often be started when the battery is dead by pushing the car into motion or allowing it to roll downhill, and then engaging the clutch in third or second gear. This is commonly known as a "push start", "popping the clutch" (in the USA) or Bump starting, which in the UK describes the action of suddenly releasing pedal.

- Manual transmissions work regardless of the orientation angle of the car with respect to gravity. Automatic transmissions have a fluid reservoir (pan) at the bottom; if the car is tilted too much, the fluid pump can be starved, causing a failure in the hydraulics. This could matter in some extreme off roading circumstances.

- It is sometimes possible to move a vehicle with a manual transmission just by putting it in gear and cranking the starter. This is useful in an emergency situation where the vehicle will not start, but must be immediately moved (from an intersection or railroad crossing, for example). It is also easier to put a car with a manual transmission into neutral, even when the transmission has suffered damage from an accident or malfunction. Many modern vehicles will not allow the starter to be run without the clutch fully depressed, negating this advantage.

5.1.7 DISADVANTAGE OF MANUAL TRANSMISSION

Many of the disadvantages of a manual transmission involve the driver interaction with the vehicle. While most of these can be overcome with practice and experience, they should be considered:

1. Manual transmissions often require the driver to place their full and continuous attention on the road, which may be seen as a disadvantage. Some consider this an

advantage, as it prevents the driver from other potential distractions like cell phone or radio use.

2. Inexperienced drivers may place more of their attention on shifting the gears, potentially distracting them from the road surroundings.

3. A driver may inadvertently shift into the wrong gear with a manual transmission, potentially causing damage to the engine and transmission, or the vehicle's body and its surroundings if the intended gear was reverse. However this can be offset with a lockout on the reverse such as found on many European cars.

4. Manual transmissions require a learning curve as one must develop a feel for properly engaging the clutch.

5. While it can easily be overcome with experience, manual transmission vehicles require good gas pedal application and clutch control when starting the call from a standstill. Too many RPM's causes the car to redline, whereas not enough RPM's upon clutch release causes the engine to stall, due to the lack of momentum required to sustain the engine.

6. The smooth and quick shifts of an automatic transmission are not guaranteed when operating a manual transmission; such changes are dependent on the driver.

7. For a person with physical impairment, an automatic transmission might be the only available shifting option. The comparable systems for hand operated clutch and brakes for a manual transmission equipped car are usable only by people with just lower body handicap. Retrofit of such a system also requires extensive modifications to the car.

8. Vehicles with manual transmissions are more difficult to start from rest when stopped upward on a hill because the clutch must be depressed and the gas applied very quickly once the brake is removed to prevent slipping backward. However, this can be overcome with experience and/ or the use of the handbrake.

9. The clutch disc is a wear item and must be replaced periodically. While this is typically a labor intensive process that can be an expensive service, it shouldn't

prove more expensive than periodic service to an automatic transmission in the long run.

5.1.8 APPLICATION OF MANUAL TRANSMISSION SYSTEM

Many types of automobiles are equipped with manual transmissions. Small economy cars predominantly feature manual transmissions because they are relatively cheap and efficient, although many are or may be optionally equipped with automatics. Economy cars are also often powered by very small engines, and automatic transmissions can make them comparatively very slow, while a manual transmission makes much more efficient use of the power produced.

Sports cars are also often equipped with manual transmissions because they offer more direct driver involvement and better performance. Off-road vehicles and trucks often feature manual transmissions because they allow direct gear selection and are often more rugged than their automatic counterparts.

Very heavy trucks also feature manual transmissions because they are efficient and, more importantly, can withstand the severe stress encountered in hauling heavy loads. Small economy cars predominantly feature manual transmissions because they are relatively cheap and efficient, although many are or may be optionally equipped with automatics.

5.1.9 MAINTENANCE

Because clutches use changes in friction to modulate the transfer of torque between engine and transmission, they are subject to wear in everyday use. A very good clutch, when used by an expert driver, can last hundreds of thousands of kilometers (100,000 kilometres is equal to 62,137 miles). Weak clutches, abrupt downshifting, inexperienced drivers, and aggressive driving can lead to more frequent repair or replacement.

Manual transmissions are lubricated with gear oil, which must be changed periodically in some cars, although not as frequently as the automatic transmission fluid in a vehicle so equipped. (Some manufacturers specify that changing the gear oil is never necessary except after transmission work or to rectify a leak.)

Gear oil has a characteristic aroma due to the addition of molybdenum disulfide compounds. These compounds are used to reduce the high sliding friction by the helical gear cut of the teeth (this cut eliminates the characteristic whine of straight cut spur gears). On motorcycles with "wet" clutches (clutch is bathed in engine oil), there is usually nothing separating the lower part of the engine from the transmission, so the same oil lubricates both the engine and transmission.

5.2 CLUTCH AND ITS FUNCTION

Clutch is a device used in transmission system of motor vehicle to engage and disengage the engine to the transmission. Thus, the clutch is located between the engine and transmission. When the clutch is engaged, the power flows from the engine to the rear wheels through the transmission system and the vehicle moves. When the clutch is disengaged, the power is not transmitted to the rear wheels and the vehicle stops while the engine, is still running. The clutch is disengaged, when starting the engine, when shifting the gears, when stopping the vehicle and when idling the engine. The clutch is engaged only when the vehicle is to move and is kept engaged when the vehicle is moving. The clutch also permits the gradual taking up of the load. When operated properly, it prevents jerky motion of the vehicle and thus avoids putting under strain on the remaining parts of the power transmission system.

5.2.1 PRINCIPLE OF OPERATION

The clutch works on the principle of friction. When two friction surfaces are brought in contact with each other and pressed they are united due to the friction between them. If now one is revolved, the other one also revolve. The friction between the two surfaces depends upon the area of surfaces, pressure applied upon them and coefficient of friction of the surface materials. The two surfaces can be separated and brought into contact when required. One surface is considered as driving member and other as driven member. The driving member is kept rotating. When the driven member is brought in contact with the driving member, it also starts rotating. When the driven member is separated from the driving member it does not revolve. This is the principle on which the clutch operates.

The friction surfaces of the clutch are so designed that the driven member slips on the driving member when the pressure is applied. As pressure increase the driven member is brought gradually to the speed of the driving member. When the speed of the members become equal, there is no slip, the two members are in firm contact and the clutch is said to be fully engaged.

The driving member of a clutch is flywheel mounted on the crankshaft, the driven member is the pressure plate mounted on the transmission shaft. Friction surfaces are between the two members. When the clutch is engaged, the engine is connected to the transmission and the power flows from the engine to the rear wheels through the transmission system. When the clutch is disengaged by passing a clutch pedal, the engine is disconnected to the transmission. Thus, the power does not flow to the rear wheels while the engine is still running.

5.2.2 REQUIREMENT OF A CLUTCH

1. **Torque transmission**: The clutch should be able to transmit maximum torque of the engine.

2. **Gradual engagement:** The clutch should engage gradually to avoid sudden jerks.

3. **Heat dissipation:** The clutch should be able to dissipate large amount of heat which is generated during the clutch operation due to friction.

4. **Dynamic balancing:** The clutch should be dynamically balanced. This is particularly required in the case of high speed engine clutches.

5. **Vibration damping:** The clutch should have suitable mechanism to damp vibrations and to eliminate noise produced during the power transmission.

6. **Size:** The clutch should be as small as possible in size so that it will occupy minimum space.

7. **Free pedal play:** The clutch should have free pedal play in order to reduce effective clamping load on the carbon thrust bearing and wear on it.

8. **Easy in operation:** The clutch should be easy to operate requiring as little exertion as possible on the part of the driver.

9. **Lightness:** The driven member of the clutch should be as light as possible so it will not continue to rotate for any length of time after the clutch has been disengaged.

5.2.3 TYPES OF FRICTION MATERIALS

The friction materials of the clutch plate are generally of three types:

1. Mill board type,
2. Moulded type,
3. Woven type.

Mill board type friction materials mainly include asbestos sheets treated with different types of impregnates. They are cheap as well as quite satisfactory in operation.

Moulded type friction materials are made from a matrix of asbestos fibre and starch or any other suitable binding materials. They are then heated to a certain temperature for moulding in dies under pressure. They are also mad into sheets which are rolled, pressed and backed till they are extremely hard and dense. Metallic wires are also sometimes inserted to improve wearing qualities. In comparison to other types, they can take heavier working loads. The only disadvantage of this type of friction materials is that each clutch facing has to be moulded separately.

Woven type facing materials are made by impregnating a cloth with certain binders or by wearing threads of brass or copper wires covered with long fibre asbestos and cotton. The woven sheets treated with a binding solution are baked and rolled.

The woven fabrication materials are further classified into two type-laminated type and solid woven type. Laminated type friction material is prepared by holding one layer over the other with a binder between them. In the solid woven type, the cloth is woven just to the required thickness.

The most common friction materials are as follows:

1. Leather. Coefficient of friction 0.27.
2. Cork. Coefficient of friction 0.32.
3. Fabric. Coefficient of friction 0.40.
4. Asbestos. Coefficient of friction 0.20.
5. Reybestos and Ferodo. Coefficient of friction 0.20.

They are almost universally used for clutch lining.

5.2.4 PROPERTIES OF GOOD CLUTCH LINING.

1. Good wearing properties.
2. High coefficient of friction.
3. High resistant to heat.
4. Good binder in it.
5. Cheap and easy to manufacture.

5.2.5 TYPES OF CLUTCH.

1. Positive clutches
    a) Square jaw clutch.
    b) Spiral jaw clutch.
2. Friction clutches
    a) Disc or plate clutches (single disc or multiple disc clutches),

b) Cone clutches,

c) Centrifugal clutches.

The disc and cone clutches are called as axial friction clutches, while the centrifugal clutch is called radial friction clutch.

In our vehicle we used multiple disc clutch and we will discuss that in detail in the following.

5.2.6 MULTIPLATE CLUTCH.

A multiplate clutch assembly for transmission of power consists of flywheel, a clutch plate, pressure plate, clutch cover, release lever, withdrawal fork and bearing, primary or clutch shaft. These are explained below:

1) Flywheel:

A clutch plate is attached on the machined surface of the flywheel sandwiched between the flywheel and the pressure plate. A pilot bearing or bush supporting the spigot end of the primary shaft (going to the gear box)is also housed in the flywheel. It is also the second driving member.

2) Clutch plate or disc:

It is the main driven member of the multi plate clutch. It is lined with friction material on its bearing surfaces. It consists of a central hub machined with internal splines to limit the axial travel along the splined gear box driving shaft. A cushion drive clutch plate is provided with modern motor vehicles. It helps to provide a damping action against the torsional vibrations or variations of the driving torque between engine and the transmission. By coupling the splined centre hub to the driven plate with the help of a flexible mounting, the damping action is achieved.

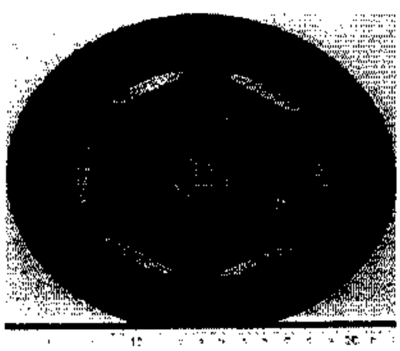


FIG 5.2.6 CLUTCH PLATE

3) Pressure plate:

It presses the clutch plate on to the flywheel from its machined surface. Between the pressure plate and the clutch cover assembly, pressure springs are fitted. The pressure plate will be withdrawn from the flywheel whenever the release levers are depressed by the toggles or release levers are pivot accordingly. To fit in corresponding slots provided in the clutch cover, three or four machined lugs are usually provided on the pressure plate.

4) Clutch cover:

It is one of the driving member of the clutch assembly. Bolted to flywheel, it includes the pressure plate, toggle lever or release lever mechanism. Generally the clutch plate revolves with the flywheel. But when the clutch is disengaged, the flywheels as well as the pressure plates are free to revolve independently from the driven plate and driving shaft.

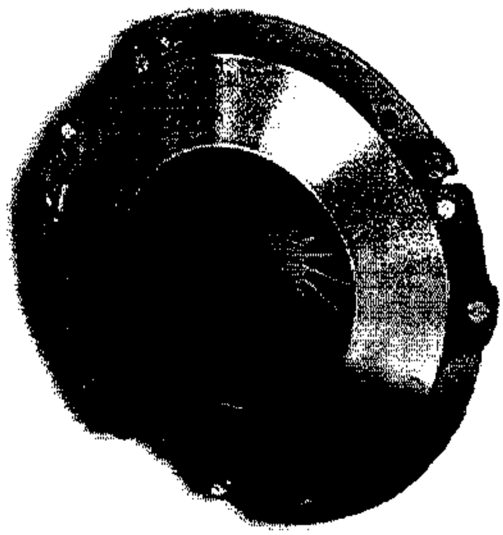


FIG 5.2.6.a CLUTCH COVER

5) Release levers:

These are provided on pins in the clutch cover. Their outer ends are located and positioned on pressure plate lugs and the inner ends are projecting towards the clutch shaft.

6) Withdrawal fork and bearing:

The withdrawal fork carrying the withdrawal bearings is pivoted on a ball mounted in the clutch outer casing. The bearing is generally facing the inner ends of the toggle lever. By means of rods and levers the other ends of fork is connected to the clutch pedal.

7) Primary or Clutch shaft:

In general, it is a component of the gear box. It is also known as the driving shaft of a gear box. Since it is splined to the hub of the clutch plate which is sliding on it, it is also known as the clutch shaft. It has one end supported in a spigot bush in the centre of the crank shaft or flywheel while the other rear end passing through a bearing in the gear box carries one of the constant mesh gears.

5.2.6.a CONSTRUCTION

Multiplate clutch consists of a number of clutch plates, instead of only one clutch plate as is the case of single plate clutch. As the number o clutch plates are increased, the friction surfaces also increase. The increased number of friction surfaces obviously increases the capacity of the clutch to transmit torque. The plates are alternately fitted to the engine shaft and the gear box shaft. They are firmly pressed by strong coil springs and assembled in a drum. Each of the alternate plate slides in grooves on the pressure plate. Thus, each alternate plate has inner and outer splines.

The multiplate clutches may be dry or wet. When the clutch is operated in an oil bath, it is called a wet clutch. When the clutch is operated dry, it is called dry clutch. The wet clutches are generally used in conjunction with, or as a part of the automatic transmission.

5.2.6.b WORKING

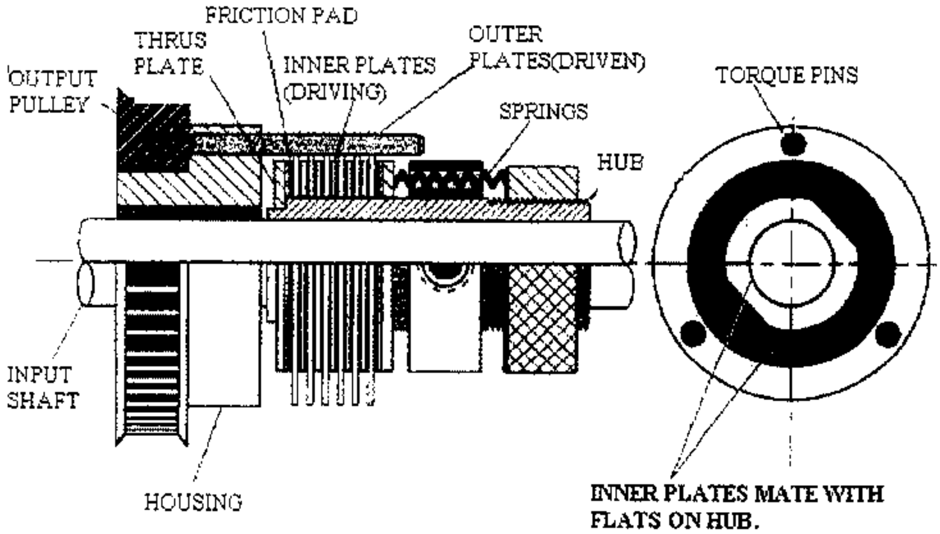


FIG 5.2.6.b MULTIPLATE CLUTCH

When the clutch pedal is pressed down, its linkages forces the thrust release bearing to move in towards the flywheel and pressing the longer ends of the lever inwards. The levers are forced to turn on their suspended pivot and the pressure plate moves away from the flywheel by the knife edges, thereby compressing the clutch springs. This action removes the pressure from the flywheel and the driven shaft becomes stationary. On the other hand, when the foot is taken off from the clutch pedal, the thrust bearings moves back by the levers. This allows the springs to extend and thus the pressure plate pushes the clutch plate back towards the flywheel.

5.2.6.c APPLICATIONS

The multi plate clutches are used in

i. Heavy commercial vehicles
ii. Racing cars and
iii. Motor cycles for transmitting high torque.

5.2.7 CLUTCH TROUBLE SHOOTING

It is not within the scope of this book to deal with very exhaustively the trouble shooting of the automobile clutch. However, common troubles experienced along with their causes, are explained below briefly. The remedies have along been suggested.

1. Clutch Slip

It is sometimes experienced that the clutch slips while in engagement. In this condition it fails to transmit completely the engine torque. Moreover, because of slipping, a large amount of heat is generated due to which clutch facings wear out rapidly and even burn out. The flywheel face also wears out, there is rapid wear of pressure plate and the stiffness of the springs is also decreased. This may be caused by any or more of the following reasons:

(a) Incorrect linkage adjustment which causes insufficient 'free pedal play'. Adjustment of the linkage will remedy this defect.

(b) Oil or grease on friction facings due to leakage from the engine crankcase or the gear box or to excessive lubrication of the clutch shaft and its support bearing. This cause glazing of the friction surfaces leading to slipping. The remedy in this case is simply to clean the components and replace the clutch facing.

(c) Weak or broken clutch springs. The springs may be overheated, which will be revealed by their blue colour. Overheating reduces the spring stiffness and makes them weak. In this case the only alternative is to replace the springs.

(d) Worn out facings, which should be replaced.

2. Clutch Drag or Spin

Sometimes when the clutch is to be disengaged, it is not disengaged, completely and it causes difficulty in changing the gears. This defect is called clutch drag. Reasons for the presence of this defect may be:

(a) Excessive "free pedal play". This may have been caused by the driver "riding" the clutch pedal. i.e., when he is in the habit of keeping his foot on the clutch pedal while driving. When the clutch drags, the first thing to be done is to check the 'free pedal play'. If found incorrect, it should be adjusted. If this play is already correct, then the trouble may be due to other reasons and to locate them the clutch has to be opened.

(b) Oil or grease on friction facings. The remedy is to clean the facings or if excessively damaged, to replace them.

(c) Pressure plate warped or damaged. This needs replacement.

(d) Clutch plate cracked or buckled. The only alternative to remedy this is the replacement of the complete plate.

(e) Clutch plate may be seized on clutch shaft splines. This may be remedied by cleaning up the splines on the shaft and lubricating them.

3. Clutch Judder

Sometimes as the clutch is engaged, a vibration or judder is produced instead of smooth gradual engagement and the vehicle suddenly jumps forward. The possible causes are:

(a) Loose or worn out clutch facings, which must be replaced.

(b) Loose rivets. The whole facing should be replaced.

(c) Distorted clutch plate may also be one of the reasons to cause clutch judder. The same has to be replaced.

(d) Misalignment of the pressure plate with the fly wheel. This has to be corrected. This requires, however, special equipment.

(e) Fly wheel may loose on the crankshaft flange, which may be tightened to remove the defect.

(f) Bent splinted clutch shaft. If the defect is not much, it may be possible to straighten the shaft; otherwise this has to be replaced.

(g) Oil, grease or dirt on the friction surfaces causing uneven engagement. The friction surfaces on the flywheel and the pressure plate should be cleaned ant the clutch facing replaced.

4. Clutch Rattle

Apart from the defects explained earlier in the engagement of clutches, some peculiar noises may be noticeable when the engine is idling. Clutch rattle is the prominent noise observed.

To locate the cause, press the clutch pedal to take up only the free movement. If the rattle disappears, it may be that pedal return spring is disconnected and is loose. In the former case, the bearing has to be replaced, while in the latter case, the spring is simply to be replaced.

If, however, the rattle continues, it may be due to damaged clutch plate in which it has to be replaced. The bent splined shaft may also be a source of rattle.

5. Knock

This is observed clearly when the engine is idling and the clutch is engaged. This may be due to worn out splines of the clutch plate hub or the clutch shaft. Such a situation would require replacement of the defective part i.e. either the clutch plate or the clutch shaft or both. The wearing out of the spigot bearing in the flywheel may also be a cause of knock in the clutch. The bearing will have to be replaced in the case.

6. Pulsation of the clutch pedal

This may be caused by the misalignment of the engine and the transmission. Due to misalignment, the clutch disc moves to and fro on the clutch shaft in each revolution and this movement is transmitted back to the pedal. This results in rapid wear of all the clutch parts. To remedy this, the proper realignment has to be done. The pedal pulsations may also be caused by a wobbling flywheel, mostly due to its improper mounting on the engine crank shaft, which may be redone properly. If the flywheel is otherwise unbalanced, the same may be either balanced or replaced.

5.3 STEERING SYSTEM

Primary function of the steering system is to achieve angular motion of the front wheels to turn. This is done through linkage and steering gear which convert the rotary motion of the steering wheel into angular motion of the front road wheels. Secondary functions of steering system are:

1. To provide directional stability of the vehicle going straight ahead.
2. To provide perfect steering condition, i.e., perfect rolling motion of the road wheels at all times.
3. To facilitate straight ahead recovery after completing a turn.
4. To minimize tyre wear.

5.3.1 REQUIREMENTS OF A GOOD STEERING SYSTEM

1. The steering mechanism should be very accurate and easy to handle.
2. The effort required to steer should be minimal and must not be tiresome to the driver.
3. The steering mechanism should also provide directional stability. This implies that the vehicle should have a tendency to return to its straight ahead position after turning.

5.3.2 TYPES OF STEERING GEARS

The different types of steering gears are as follows

1. Worm and roller

2. Worm and sector
3. Cam and roller
4. Cam and peg
5. Screw and nut.
6. Recirculating ball
7. Worm and worm wheel.
8. Rack and pinion

5.3.2.a RACK AND PINION GEAR

We will discuss about this gear in detail as it is employed in our vehicle for its easy operation, availability and economic.

It is actually a pretty simple mechanism. A rack-and-pinion gear set is enclosed in a metal tube, with each end of the rack protruding from the tube. A rod, called a tie rod, connects to each end of the rack.

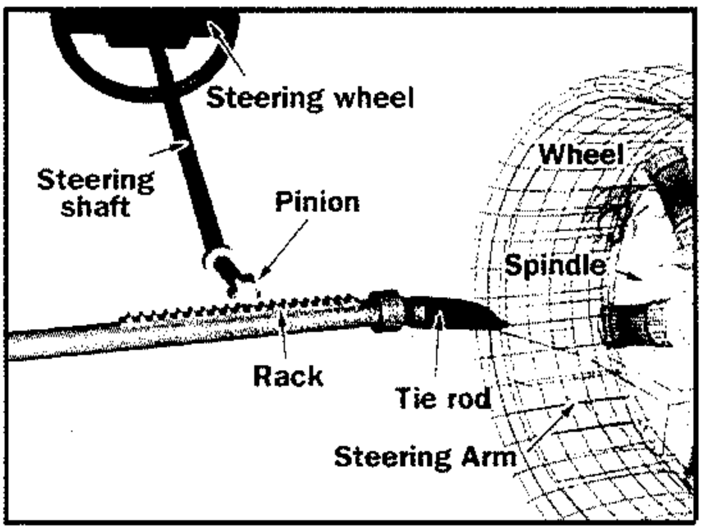


FIG 5.3.2.a RACK AND PINION STEERING SYSTEM

The pinion gear is attached to the steering shaft. When you turn the steering wheel, the gear spins, moving the rack. The tie rod at each end of the rack connects to the steering arm on the spindle (see diagram above).

The rack-and-pinion gear set does two things:

- It converts the rotational motion of the steering wheel into the linear motion needed to turn the wheels.
- It provides a gear reduction, making it easier to turn the wheels.

5.3.3 STEERING RATIO

The steering ratio is the ratio of how far you turn the steering wheel to how far the wheels turn. For instance, if one complete revolution (360 degrees) of the steering wheel results in the wheels of the car turning 20 degrees, then the steering ratio is 360 divided by 20, or 18:1. A higher ratio means that you have to turn the steering wheel more to get the wheels to turn a given distance. However, less effort is required because of the higher gear ratio.

5.3.4 WHEEL ALIGNMENT

In its most basic form, a wheel alignment consists of adjusting the angles of the wheels so that they are perpendicular to the ground and parallel to each other. The purpose of these adjustments is maximum tire life and a vehicle that tracks straight and true when driving along a straight and level road.

Wheel Alignment is often confused with Wheel Balancing. The two really have nothing to do with each other except for the fact that they affect ride and handling. If a wheel is out of balance, it will cause a vibration at highway speeds that can be felt in the steering wheel and/or the seat. If the alignment is out, it can cause excessive tire wear and steering or tracking problems.

Some of the wheel alignments are

a) Camber

Camber is the angle of the wheel, measured in degrees, when viewed from the front of the vehicle. If the top of the wheel is leaning out from the center of the car, then the camber is positive, if it's leaning in, then the camber is negative. If the camber is out of adjustment, it will cause tire wear on one side of the tire's tread. If the camber is too far negative, for instance, then the tire will wear on the inside of the tread.

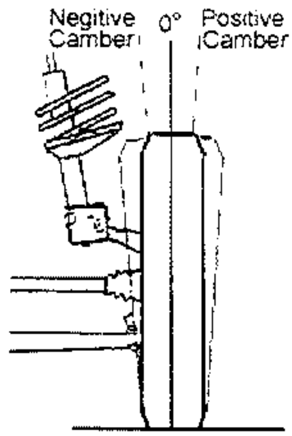


FIG 5.3.3.a CAMBER

If the camber is different from side to side it can cause a pulling problem. The vehicle will pull to the side with the more positive camber. On many front-wheel-drive vehicles, camber is not adjustable. If the camber is out on these cars, it indicates that something is worn or bent, possibly from an accident and must be repaired or replaced.

FIG 5.3.3.b CAMBER WEAR PATTERN

b) Caster

When you turn the steering wheel, the front wheels respond by turning on a pivot attached to the suspension system. Caster is the angle of this steering pivot, measured in degrees, when viewed from the side of the vehicle. If the top of the pivot is leaning toward the rear of the car, then the caster is positive, if it is leaning toward the front, it is negative. If the caster is out of adjustment, it can cause problems in straight line tracking. If the caster is different from side to side, the vehicle will pull to the side with the less positive caster. If the caster is equal but too negative, the steering will be light and the vehicle will wander and be difficult to keep in a straight line. If the caster is equal but too positive, the steering will be heavy and the steering wheel may kick when you hit a bump. Caster has little affected on tire wear.

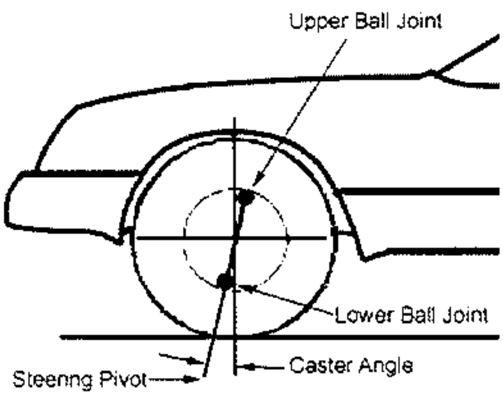


FIG5.3.3.c CASTER

The best way to visualize caster is to picture a shopping cart caster. The pivot of this type of caster, while not at an angle, intersects the ground ahead of the wheel contact patch. When the wheel is behind the pivot at the point where it contacts the ground, it is in positive caster. Picture yourself trying to push the cart and keep the wheel ahead of the pivot. The wheel will continually try to turn from straight ahead. That is what happens when a car has the caster set too far negative. Like camber, on many front-wheel-drive vehicles, caster is not adjustable. If the caster is out on these cars, it indicates that something is worn or bent, possibly from an accident, and must be repaired or replaced.

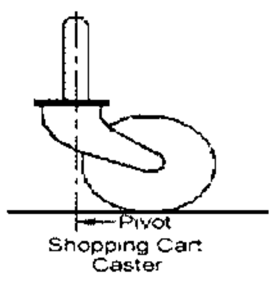


FIG 5.3.3.d SHOPPING CART CASTER

C) Toe-In

The toe measurement is the difference in the distance between the front of the tires and the back of the tires. It is measured in fractions of an inch in the US and is usually set close to zero which means that the wheels are parallel with each other. Toe-in means that the fronts of the tires are closer to each other than the rears. Toe-out is just the opposite. An incorrect toe-in will cause rapid tire wear to both tires equally. This type of tire wear is called a saw-tooth wear pattern as shown in this illustration.

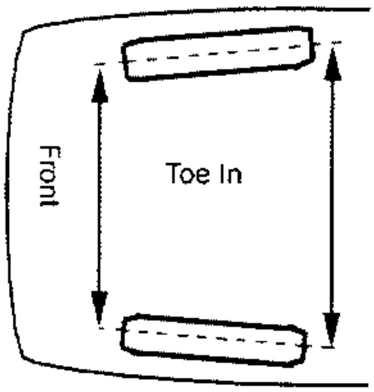


FIG 5.3.3.e TOE-IN

If the sharp edges of the tread sections are pointing to the center of the car, then there is too much toe-in. If they are pointed to the outside of the car then there is too much toe-out. Toe is always adjustable on the front wheels and on some cars, is also adjustable for the rear wheels.

d) Toe-Out

When you steer a car through a turn, the outside front wheel has to navigate a wider arc then the inside wheel. For this reason, the inside front wheel must steer at a sharper angle than the outside wheel.

Toe-out on turns is measured by the turning angle gauges (turn plates) that are a part of every wheel alignment machine. The readings are either directly on the turn plate or they are measured electronically and displayed on the screen. Wheel alignment specifications will usually provide the measurements for toe-out on turns. They will give an angle for the inside wheel and the outside wheel such as 20Â° for the inside wheel and 18Â° for the outside wheel. Make sure that the readings are at zero on each side when the wheels are straight ahead, then turn the steering wheel so that the inside wheel is at the inside spec. then check the outside wheel.

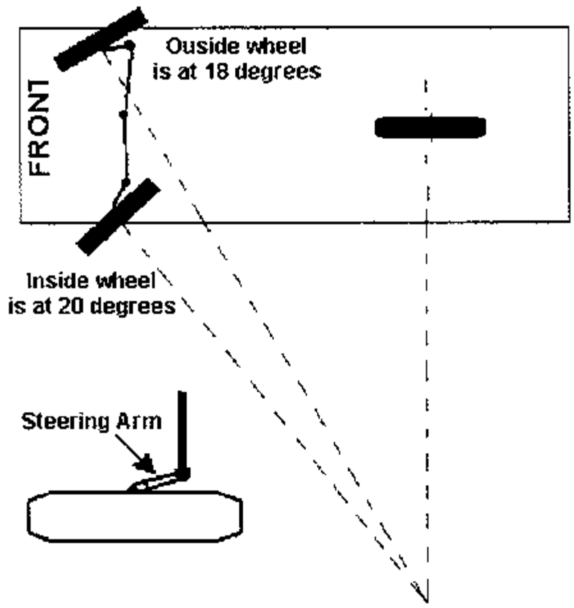


FIG 5.3.3.f TOE-OUT

The toe-out angles are accomplished by the angle of the steering arm. This arm allows the inside wheel to turn sharper than the outside wheel. The steering arm is either part of the steering knuckle or part of the ball joint and is not adjustable. If there is a problem with the toe-out, it is due to a bent steering arm that must be replaced.

5.3.4.a THREE WHEEL ALIGNMENTS

There are two main types of 3-wheel alignments. In each case, the technician will place an instrument on all three wheels. In the first type the rear toe and tracking is checked, but all adjustments are made at the front wheels. This is done on vehicles that do not have adjustments on the rear. The second type is a full 3-wheel alignment where the adjustments are first made to true up the rear alignment, then the front is adjusted. A full 3-wheel alignment will cost more than the other type because there is more work involved.

5.3.5 OTHER FACTS EVERY DRIVER SHOULD KNOW ABOUT WHEEL ALIGNMENTS.

- A proper wheel alignment should always start and end with a test drive.
- The front end and steering linkage should be checked for wear before performing an alignment.
- The tires should all be in good shape with even wear patterns. If you have a tire with excessive camber wear, for instance, and you correct the alignment problem that caused that wear, the tire will now be making only partial contact with the road. (see illustration on right)
- Pulling problems are not always related to wheel alignment. Problems with tires (especially unequal air pressure), brakes and power steering can also be responsible. It is up to a good wheel alignment technician to determine the cause.

5.3.6 ADVANCED WHEEL ALIGNMENT INFORMATION.

While Camber, Caster & Toe-in are the settings that are always checked when doing a wheel alignment, they are not the only settings. Below is a list of the alignment settings that are important for a wheel alignment technician to know about in order to diagnose front end problems.

5.4 SUSPENSION SYSTEM

The job of a car suspension is to provide steering stability with good handling and to ensure the comfort of the passengers. In this article, we'll explore how car suspensions work, how they've evolved over the years and where the design of suspensions is headed in the future.

If a road were perfectly flat, with no irregularities, suspensions wouldn't be necessary. But roads are far from flat. Even freshly paved highways have subtle imperfections that can interact with the wheels of a car. It's these imperfections that apply forces to the wheels. According to Newton's laws of motion, all forces have both magnitude and direction. A bump in the road causes the wheel to move up and down perpendicular to the road surface. The magnitude, of course, depends on whether the wheel is striking a giant bump or a tiny speck. Either way, the car wheel experiences a vertical acceleration as it passes over an imperfection

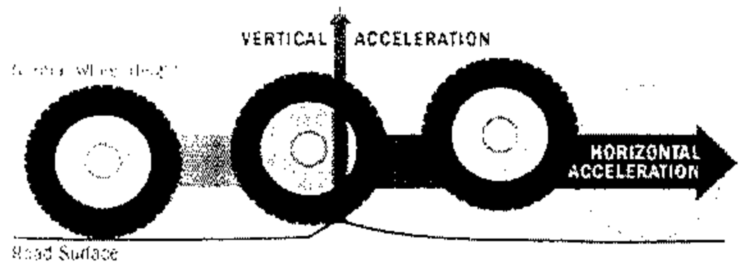


FIG 5.4 VERTICAL/HORIZONTAL ACCELERATION.

Without an intervening structure, all of wheel's vertical energy is transferred to the frame, which moves in the same direction. In such a situation, the wheels can lose contact with the road completely. Then, under the downward force of gravity, the wheels can slam back into the road surface. What you need is a system that will absorb the energy of the vertically accelerated wheel, allowing the frame and body to ride undisturbed while the wheels follow bumps in the road.

The study of the forces at work on a moving car is called vehicle dynamics, and you need to understand some of these concepts in order to appreciate why a suspension is necessary in the first place. Most automobile engineers consider the dynamics of a moving car from two perspectives:

- **Ride** - a car's ability to smooth out a bumpy road
- **Handling** - a car's ability to safely accelerate, brake and corner

These two characteristics can be further described in three important principles - road isolation, road holding and cornering. The table below describes these principles and how engineers attempt to solve the challenges unique to each.

TABLE 5.4
THE PERSPECTIVES ABOUT THE DYNAMICS OF A MOVING CAR

Principle	Definition	Goal	Solution
Road Isolation	The vehicle's ability to absorb or isolate road shock from the passenger compartment	Allow the vehicle body to ride undisturbed while traveling over rough roads.	Absorb energy from road bumps and dissipate it without causing undue oscillation in the vehicle.
Road Holding	The degree to which a car maintains contact with the road surface in various types of directional changes and in a straight line (Example: The weight of a car will shift from the rear tires to the front tires during braking. Because the nose of the car dips toward the road, this type of motion is known as "dive." The opposite effect "squat" occurs during acceleration, which shifts the weight of the car from the front tires to the back.)	Keep the tires in contact with the ground, because it is the friction between the tires and the road that affects a vehicle's ability to steer, brake and accelerate.	Minimize the transfer of vehicle weight from side to side and front to back, as this transfer of weight reduces the tire's grip on the road.

Cornering	The ability of a vehicle to travel a curved path	Minimize body roll, which occurs as centrifugal force pushes outward on a car's center of gravity while cornering, raising one side of the vehicle and lowering the opposite side.	Transfer the weight of the car during cornering from the high side of the vehicle to the low side.

5.4.1 FUNCTION OF SUSPENSION SYSTEM

- To prevent the road shocks from being transmitted to the vehicle frame.
- To preserve the stability of vehicle in pitching or rolling, while in motion. To safeguard the occupants from road shocks.
- To provide good road holding while driving and cornering.
- To maintain proper steering geometry.

5.4.2 REQUIREMENTS OF A SUSPENSION SYSTEM

- Minimum deflection consistent, with the required stability.
- Comparability with other vehicle components-type, frame, wheel base, steering linkage.
- Minimum wheel hop.
- Low maintenance and operating costs.
- Low initial cost.

5.4.3 CAR SUSPENSION PARTS

The suspension of a car is actually part of the chassis, which comprises all of the important systems located beneath the car's body.

These systems include:

- The frame - structural, load-carrying component that supports the car's engine and body, which are in turn supported by the suspension.

- The suspension system - setup that supports weight, absorbs and dampens shock and helps maintain tire contact.

- The steering system - mechanism that enables the driver to guide and direct the vehicle.

- The tires and wheels - components that make vehicle motion possible by way of grip and/or friction with the road.

So the suspension is just one of the major systems in any vehicle.

With this big-picture overview in mind, it's time to look at the three fundamental components of any suspension: springs, dampers and anti-sway bars.

Springs

Today's springing systems are based on one of four basic designs:

- Coil springs - This is the most common type of spring and is, in essence, a heavy-duty torsion bar coiled around an axis. Coil springs compress and expand to absorb the motion of the wheels.

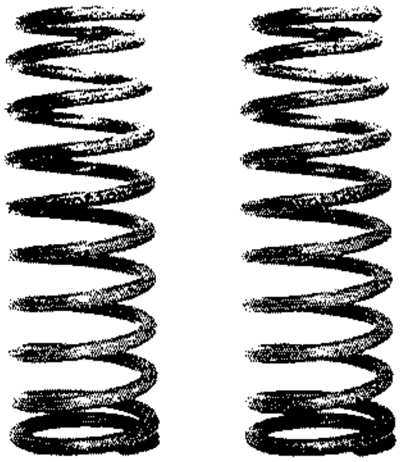


FIG 5.4.3.a COIL SPRING

- Leaf springs - This type of spring consists of several layers of metal (called "leaves") bound together to act as a single unit. Leaf springs were first used on horse-drawn carriages and were found on most American automobiles until 1985. They are still used today on most trucks and heavy-duty vehicles.

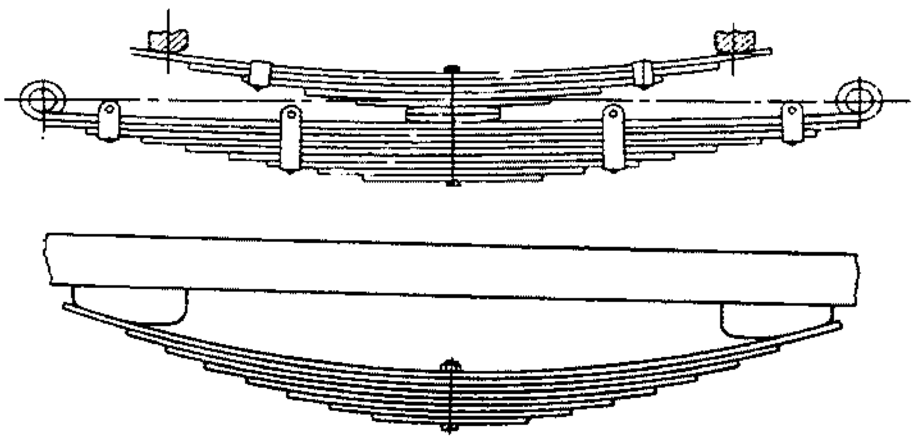


FIG 5.4.3.b LEAF SPRING

- Torsion bars - Torsion bars use the twisting properties of a steel bar to provide coil-spring-like performance. This is how they work: One end of a bar is anchored to the vehicle frame. The other end is attached to a wishbone, which acts like a lever that moves perpendicular to the torsion bar. When the wheel hits a bump, vertical motion is transferred to the wishbone and then, through the levering action, to the torsion bar. The torsion bar then twists along its axis to provide the spring force.

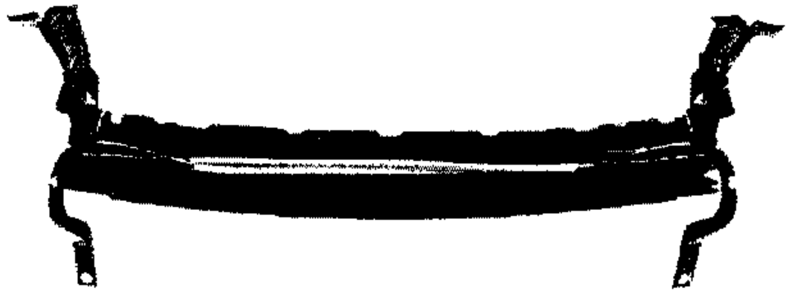


FIG 5.4.3.c TORSION BAR

- Air springs - Air springs, which consist of a cylindrical chamber of air positioned between the wheel and the car's body, use the compressive qualities of air to absorb wheel vibrations. The concept is actually more than a century old and could be found on horse-drawn buggies. Air springs from this era were made from air-filled, leather diaphragms, much like a bellows; they were replaced with molded-rubber air springs in the 1930s.

Based on where springs are located on a car -- i.e., between the wheels and the frame -- engineers often find it convenient to talk about the sprung mass and the unsprung mass.

Springs: The sprung mass is the mass of the vehicle supported on the springs, while the unsprung mass is loosely defined as the mass between the road and the suspension springs. The stiffness of the springs affects how the sprung mass responds while the car is being driven. Loosely sprung cars, such as luxury cars (think Lincoln Town Car), can swallow bumps and provide a super-smooth ride; however, such a car is prone to dive and squat during braking and acceleration and tends to experience body sway or roll during cornering. Tightly sprung cars, such as sports cars (think Mazda Miata), are less forgiving on bumpy roads, but they minimize body motion well, which means they can be driven aggressively, even around corners.

So, while springs by themselves seem like simple devices, designing and implementing them on a car to balance passenger comfort with handling is a complex task. And to make matters more complex, springs alone can't provide a perfectly smooth ride. Why? Because springs are great at absorbing energy, but not so good at dissipating it. Other structures, known as dampers, are required to do this.

Dampers: Shock absorbers

Unless a dampening structure is present, a car spring will extend and release the energy it absorbs from a bump at an uncontrolled rate. The spring will continue to bounce at its natural frequency until all of the energy originally put into it is used up. A suspension built on springs alone would make for an extremely bouncy ride and, depending on the terrain, an uncontrollable car.

Enter the shock absorber, or snubber, a device that controls unwanted spring motion through a process known as dampening. Shock absorbers slow down and reduce the magnitude of vibratory motions by turning the kinetic energy of suspension movement into heat energy that can be dissipated through hydraulic fluid. To understand how this works, it's best to look inside a shock absorber to see its structure and function.

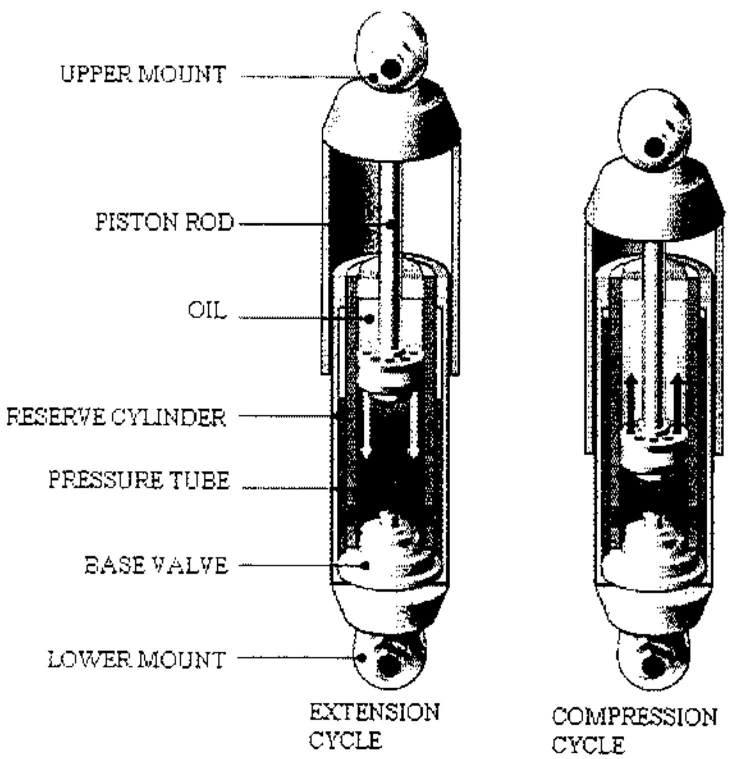


FIG 5.4.3.d TWIN TUBE SHOCK ABSORBER

A shock absorber is basically an oil pump placed between the frame of the car and the wheels. The upper mount of the shock connects to the frame (i.e., the sprung weight), while the lower mount connects to the axle, near the wheel (i.e., the unsprung weight). In a twin-tube design, one of the most common types of shock absorbers, the upper mount is connected to a piston rod, which in turn is connected to a piston, which in turn sits in a tube filled with hydraulic fluid. The inner tube is known as the pressure tube, and the outer tube is known as the reserve tube. The reserve tube stores excess hydraulic fluid.

When the car wheel encounters a bump in the road and causes the spring to coil and uncoil, the energy of the spring is transferred to the shock absorber through the upper mount, down through the piston rod and into the piston. Orifices perforate the piston and allow fluid to leak through as the piston moves up and down in the pressure tube. Because the orifices are relatively tiny, only a small amount of fluid, under great pressure, passes through. This slows down the piston, which in turn slows down the spring.

Shock absorbers work in two cycles -- the compression cycle and the extension cycle. The compression cycle occurs as the piston moves downward, compressing the hydraulic fluid in the chamber below the piston. The extension cycle occurs as the piston moves toward the top of the pressure tube, compressing the fluid in the chamber above the piston. A typical car or light truck will have more resistance during its extension cycle than its compression cycle. With that in mind, the compression cycle controls the motion of the vehicle's unsprung weight, while extension controls the heavier, sprung weight.

All modern shock absorbers are velocity-sensitive -- the faster the suspension moves, the more resistance the shock absorber provides. This enables shocks to adjust to road conditions and to control all of the unwanted motions that can occur in a moving vehicle, including bounce, sway, brake dive and acceleration squat.

We'll look at some of the common types of front and back suspensions typically used in our vehicle.

5.4.4 FRONT SUSPENSION TYPE

The front end suspension is more complicated than the rear end suspension, because the front wheels not only move up and down with respect to the car frame, but also swing at various angles to the car frame for steering. Each wheel is supported on a spindle, which is part of the steering knuckle. The steering knuckle is then supported through ball joints, by upper and lower control arms which are attached to the car frame.

5.4.5 REAR END SUSPENSION

Here shock absorbers are provided in order to care of vibrations. The working of shock absorber is discussed in the previous article.

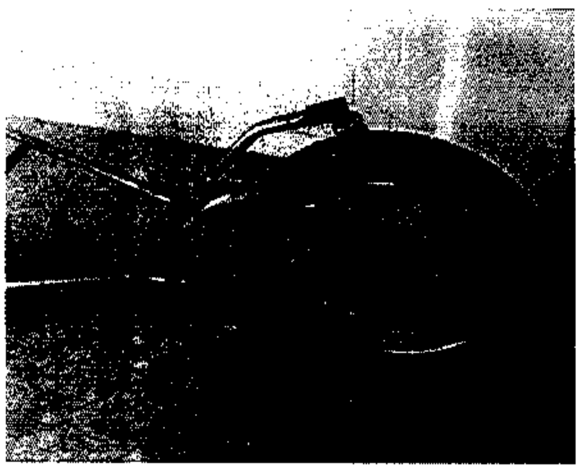


FIG 5.4.5 REAR END SUSPENSION OF OUR VEHICLE

5.5 BRAKE SYSTEM:

We know that safety of passengers in a moving vehicle depends upon the steering system and as well as good break system. The brake system calls for more efficient breaks as compared to the brake systems employed in olden days when maximum speed was much less compared to the fast running vehicles manufactured now a days.

5.5.1 REQUIREMENTS OF A GOOD BRAKING SYSTEM:

- The brakes should stop the vehicle in shortest possible distance and time.
- The brakes should work equally good, air or on bad roads.
- Pedal effort applied by the driver should not be more so as to strain the driver.
- Brakes should work equally good in all weathers.
- It should have less wearing parts.
- It should require little maintenance.
- Brakes, when applied, should not disturb steering geometry.
- When brakes are applied, the vehicle should not pull to one side.
- There should be minimum sound when brakes are applied.

5.5.2 BRAKING ACTION:

Braking action is the use of a controlled force to reduce the speed or stop a moving vehicle or to keep a vehicle stationary when braking force is applied, it develop friction, which does the braking, friction is the resistance to motion between two surfaces, thus by forcing a stationary surface into contact with moving surface, resistance to the relative motion or the rubbing action between the two surfaces will slow down the vehicle.

The increase in vehicle speed requires increase in the braking action to bring moving vehicle stop. A moving vehicle has kinetic energy, this energy increases with square of speed and must be overcome by braking action, as such if vehicle speed is doubled, its kinetic energy is increased four folds, and with this four times braking action would be required to stop such vehicles.

5.5.3 DRUM BRAKE:

In a motor vehicle, the wheel is attached to an auxiliary wheel called drum. The brake shoes are made to contact this drum. In most designs, two shoes are used with each drum mechanism at each wheel.

The brake shoes have brake linings on their outer surfaces. Each brake shoe is hinged atone end by anchor pin, the other end is operated by some means so that the shoe expands outwards the brake linings come with the drum. Retracting spring keeps the brake shoes into position when the brakes are not applied. The drum encloses the entire mechanism to keep out dust and moisture. The wheel attaching bolts on the drum are used to contact wheel and drum. The braking plate completes the brake enclosure, holds the assembly to the car axle, and acts at the base for fastening the brake shoes and operating mechanisms. The shoes is generally mounted to rub against the inside surface of the drum to form an internal expanding brake.

When the break pedal is pressed, the cam turns by means of brake linkage. When the cam turns, the shoes expand outwards against the drum. A lever is also used for the same purpose. The brake linings rub against the drum and thus stop its motion. The entire mechanical linkage between the brake pedal and the shoes operates to transmit pedal force through leverage to produce effective braking forces against the drum.

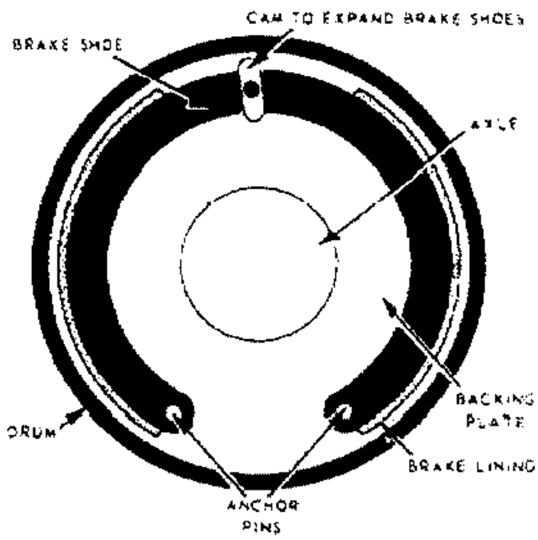


FIG 5.5.3 DRUM BRAKE

5.5.4 FACTORS INFLUENCING BRAKING EFFECT

The following are the factors responsible for affecting the ability of the brakes proper:

a) Radius of the brake drum (R_b) and of the wheel (R_w).

Retarding force produced on ground = $\mathbf{F_b * R_b / R_w}$.

Where F_b = Retarding force produced on brake drum

$= \mathbf{\mu_b * F_n}$

μ_b = coefficient of friction between the brake lining and the drum.

F_n = normal force applied on the brake shoes.

It shows that a higher brake drum radius increases the retarding force produced at the ground, while a bigger wheel would decrease it.

b) The area of the brake lining and the amount of pressure applied at the brake lining increase the braking effect directly.

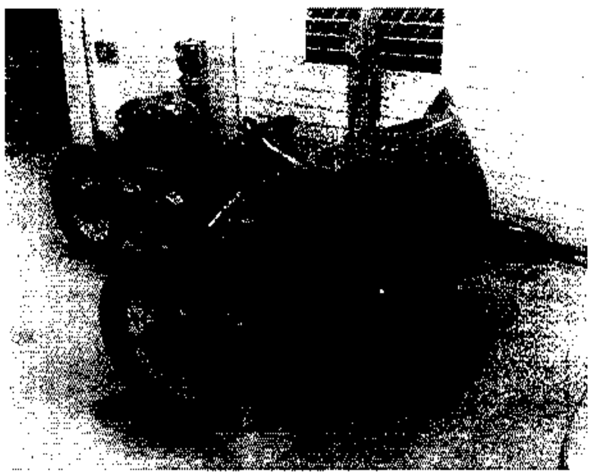
c) The higher coefficients of friction between braking surfaces and between tyre and road are also useful in increasing the braking effect, but too high coefficients may cause locking of wheels, which must be avoided.

TABLE NO: 5.5.4

TROUBLE SHOOTING TABLE FOR BRAKES AND DRUM.

Complaint	Cause	Remedy
1.Brakes fade i.e. They fail to hold on	Brake drum getting too hot.	Allow the brake and brake drum to cool.
2. Brake squeal	Rivet heads touching the brake drum.	Change the brake linings and use new rivets.
3. Brake chatter.	a) Too much brake lining. b) Poor brake adjustment. c) Brake drum out-of-round	Cut off excess material. Adjust brakes. Rebore or replace the drum.
4. Brakes grab	a) Damaged or broken brake lining. b) Badly scored brake drum.	Replace the brake lining. Rebore or replace the drum.
5.Brake drum wear	a) Brake pedal touching the foot board.	True up the brake drum; replace it, if necessary.

6. Wheel lock due to brakes	a) Broken brake shoe.	Replace the shoe.
	b) Broken lining.	Replace the lining.
	c) Loose lining.	Tighten the lining.



CHAPTER 6
FABRICATION

6.1 FABRICATION

The fabrication process of our project starts immediately after the design was completely analyzed. The procedure of our fabrication work is as follows:

The first and foremost thing in our fabrication was collection of materials for chassis fabrication.

- Purchase of raw materials:
    1. Round and square pipe.
    2. Rectangular cross section rods.
    3. Shafts.
    4. Sheet metal.
    5. Nylon bush.
- Purchase of standard elements:
    1. Diesel engine.
    2. Driver seat.
    3. Front wheel assembly.
    4. Rear wheel assembly.
    5. Suspension.
    6. Fasteners.
    7. Cables for clutch, accelerator, brake.
    8. Adjusters for cable.
    9. Steering arrangement.
    10. Head light assembly.
    11. Mud guard.
    12. Chain and sprocket.
    13. Gear box.

Some of the operations involved in fabricating chassis:

- Machining:
    1. Rack extension
    2. Bushes for A-type suspension arm.
    3. Flanges for front wheel mountings.
    4. Plates for front wheel mountings.
    5. Rear stay plates.

6. Nylon bushes for steering-universal joints and gear rods.
7. Support bushes for rack extension rods.

- Gas cutting.
- Welding.
- Pipe bending.
- Mountings
  1. Front and rear wheel.
  2. Engine.
  3. Steering.
  4. Suspension.
  5. Seat.
  6. Mud guard and fuel tank.
- Tinkering and painting.

TABLE 6.a

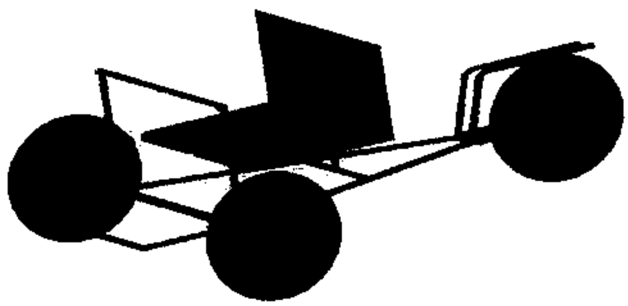
COST ESTIMATION TABLE

Part no	Description	specification	Quantity	Cost(Rs)
1.	Engine and gear box.	-	1	8000
2.	Pipe	Φ1.25".2mm thickness	-	854
3.	Circular plate	Φ7", 2mm thick	4	604
4.	Fasteners	-	-	190
5.	machining	-	-	350
6.	Steering	Rack and pinion	1	1000
7.	Front wheel assembly	-	2	800
8.	Stay bush	-	8	560
9.	Square plate	7" x 7", 2mm thick	2	330
10.	Gas cutting	Oxy-acetylene	-	30
11.	Seat	Plastic	2	500
12.	Shaft	Φ10mm	2	300
13.	Brake rod	Royal Enfield	1	65
14.	Auto spares	Royal Enfield	-	200
15.	Cables	Matador	3	300

16.	Head lamp	TVS Moped	2	400
17.	Paint	Aspa	-	1000
18.	Sheet metal	8' x 4',2mm M.S.	1	1000
19.	Overheads	-	-	500
20	Welding labour charge	-	-	3000

Total cost = 19,983.

From the above table we infer that the production cost of the vehicle is found to be Rs 19,983. let us look at the various views of the vehicle in Pro-E and reality.



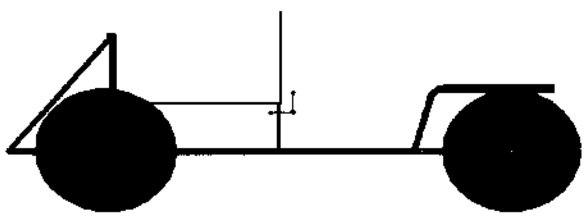


FIG 6.1 VARIOUS VIEWS OF THE VEHICLE FROM PRO-E

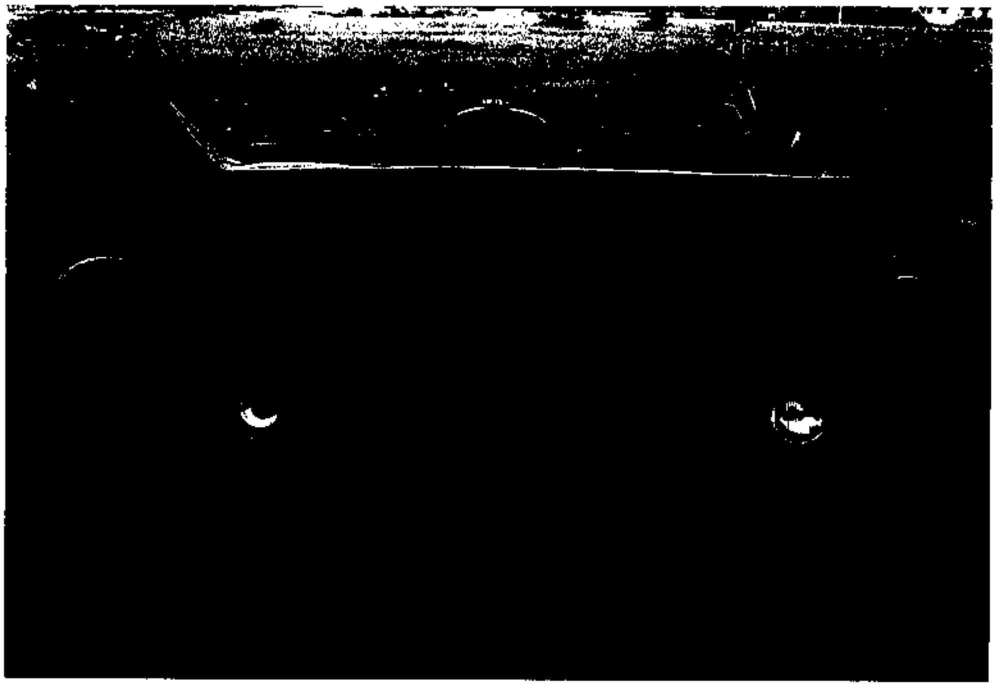
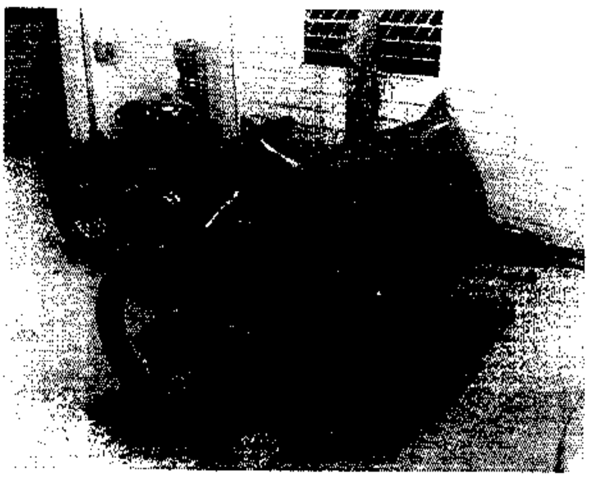


FIG 6.2 VARIOUS VIEWS OF THE VEHICLE IN REALITY.



CHAPTER 7

CONCLUSION

7. CONCLUSION

The results what we observed from ANSYS is within the permissible limits and hence the design is safe. We conclude that our project has satisfied the requirements of SRI JAYALAKSHMI INDUSTRIES, and we believe that our project would really serve well in the industrial environment.

Even though our vehicle is satisfying the objectives some modifications mentioned below will enhance its performance. Such as modification of the gear box shall be done to make the vehicle to move in reverse direction. A performance study on jatroba fuel shall be made and if the results found satisfactory it could be implemented. If dynamic analysis is done the vehicle may be used in rough terrains also.

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