Govt. Polytechnic, Sirsa

SUB: FARM TRACTOR

CHAPTER- 1
INTRODUCTION

Sources of farm power

A farm power for various agricultural operations can be broadly classified as:
(1) Tractive work such as seed bed preparation, cultivation, harvesting and transportation, and
(2) Stationary work like silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water.
These operations are done by different sources of power, namely human, animal, oil engine, tractor, power tiller, electricity and renewable energy (biogas, solar and wind).

HUMAN POWER

Human beings are the main source of power for operating small tools and implements. They are also employed for doing stationary work like threshing, winnowing, chaff cutting and lifting irrigation Water. It is generally believed that there is surplus human power available for agricultural operations in India. According to 2001 census figures, the total Indian rural population is about 74 crores. Of the total rural population only 30 per cent is available for doing farm work. Hence the total number of persons available would be about 74 x 0.30 = 22.2 crores. This figure includes both the landless labourers as well as the owners of farms in the country. On the average a man develops nearly 0.I horsepower (hp.). Therefore, the total power available through human source may be about 2.2 crore hp. But there is a steady decline in the number of landless labourers available for doing farm work in rural areas.

Advantages: Easily available and used for all types of work.

Disadvantages: Costliest power compared to all other farms of power, very low efficiency, requires full maintenance when not in use and affected by weather condition and seasons

ANIMAL POWER

The most important source of power on the farm all over the world and particularly in India is animal. It is estimated that nearly 80 per cent of the total draft power used in agriculture throughout the world is still provided by animals, although the number of agricultural tractors has become double after every ten years since 1930. India with its 22.68 crore cattle possesses the largest number of cattle in the world. Among them the bullocks and buffaloes happen to the principal sources of animal power on Indian farms. However, camels, horses, donkeys, mules and elephants are also used for the farm work. The average force a bullock can exert is nearly equal to one tenth of its body weight. But for a very short period, it can exert many more times the average force. Generally a medium size bullock can develop between 0.50 to 0.75 hp. Thus the variation in power developed by animals is considerable. Actually small size bullocks are not able to develop even 0.50 hp and most of them are not fit for heavy work. Animals Can be a very cheap source of farm power if raised by the farmer himself. It becomes the most costly source if the animal has to be bought from outside. Considering the overall situation of the draft animals available in the country, it is estimated that the total work animals may be about 7.56 crores in number, that is 33 per cent of the total horse power output from the animals would be about 7.56 x 0.50 = 3.78 crore hp.

Advantages: Easily available, Used for all types of work, Low initial investment, Supplies manure to the field and fuels to farmers and Live on farm produce.

Disadvantages: Not very efficient, Seasons and weather affect the efficiency, Cannot work at a stretch, Require full maintenance when there is no farm work, Creates unhealthy and dirty atmosphere near the residence and Very slow in doing work.

MECHANICAL POWER

The third important source of farm power is mechanical power that is available through tractors and oil engines. The oil engine is a highly efficient device for converting fuel into useful work. The efficiency of diesel engine varies between 32 and 38 per cent, whereas that of the carburettor engine is in the range of 25 and 32 per cent. In recent years, diesel engines and tractors have gained considerable popularity in agricultural operations. Small pumping sets within 3 to 10 hp range are very much in demand. Likewise, oil engines of low to medium speed developing about 14 to 20 hp are successfully used for flourmills, oil ghanis, cotton gins, etc. Diesel engines of the larger size are used on tractors. It is estimated that about one million tractors of about 25 bhp range are in use for agricultural operations in India. Similarly, the total number of oil engines for stationary work may be taken as about 60 lakhs of 5 hp each. Thus the total power available from mechanical source would work out to be 55 million hp (Oil engines = 0.60 x 5 = 3.0 crore hp, tractors = 0.1 × 25 = 2.50 crore hp. **Advantages:** Efficiency is high; not affected by weather; can run at a stretch; requires less space and cheaper form of power.

Disadvantages: Initial capital investment is high; fuel is costly and repairs and maintenance needs technical knowledge.

ELECTRICAL POWER

Now-a-days electricity has become a very important source of power on farms in various states of the country. It is steadily becoming more and more available with the increase of various river valley projects and thermal stations. On an average about 1/10th of the total electrical power generated in India, is consumed for the farm work. The largest use of electric power in the rural areas is for irrigation and domestic water supply. Besides this, the use of electric power in dairy industry, cold storage, fruit processing and cattle feed grinding has tremendously increased.

Advantages: Very cheap form of power; high efficiency; can work at a stretch; maintenance and operating cost is very low and not affected by weather conditions.

Disadvantages: Initial capital investment is high; require good amount of technical knowledge and it causes great danger, if handled without care.

WIND POWER

The availability of wind power for farm work is quite limited. Where the wind velocity is more than 32 kmph, wind mills can be used for lifting water. Even today in India the wind power has not been fully harnessed. The most important reason is its uncertainty.

Experimental results show that a wind mill having 3.6 diameter wheel mounted on 12.0 m tower is able to produce from 0.1 to 0.9 hp with the wind velocity varying from 6.4 to 37 km/h. Thus the average capacity of a wind mill would be about 0.50 hp. There are about 2540 mills installed in India. Hence the total output may be about 1250 hp only, but it is one of the cheapest sources of farm power available in the country.

Ministry of Non-Conventional Energy, Govt. of India have been making efforts to popularise the wind mill for power generation and water lifting in rural areas. But this source could not become attractive due to the following limitations of the system:

- Initial investment is high,
- Repair facilities are not available in rural areas,
- Even the matching pump sets and electric generators are not readily available in the country,
- It not suitable for all situations in the country.

For the present, the wind mills have limited scope of the use in the country.

Farm mechanization

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity. The effective mechanization contributes to increase production in two major ways: firstly the timeliness of operation and secondly the good quality of work. The requirement of power for certain operations like seedbed preparation, cultivation and harvesting becomes so great that the existing human and animal power in the country appears to be inadequate. As a result, the operations are either partially done or sometimes completely neglected, resulting in low yield due to poor growth or untimely harvesting or both.

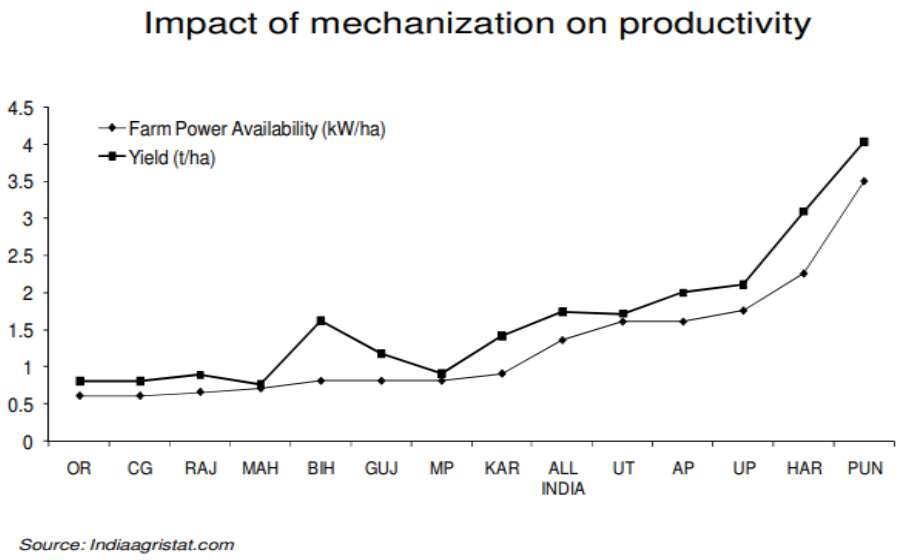


Fig. State-wise farm power availability and its impact (kW/ha)

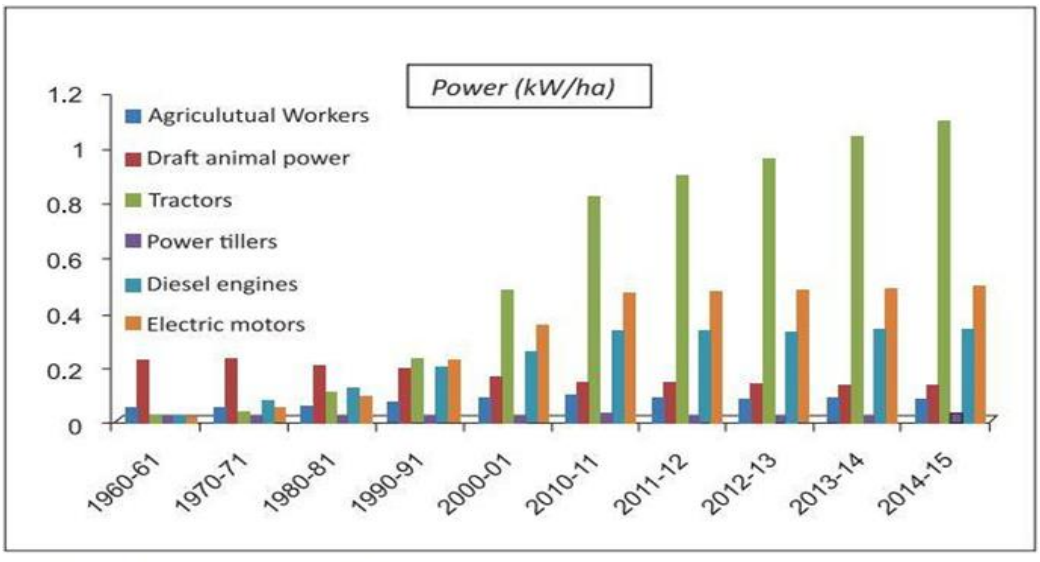


Fig. Different types of farm power available

SCOPE OF MECHANIZATION

It is quite true that the Indian farmers have the lowest earnings per capita because of the low yield per hectare they get from their holdings. One of the few important means of increasing farm production per hectare is to mechanize it. Mechanization in India may have to be done at various levels.

Broadly, it can be done in three different ways:

I. By introducing the improved agricultural implements on small size holdings to be operated by bullocks.
II. By using the small tractors, tractor-drawn machines and power tillers on medium holdings to supplement existing sources.
III. By using the large size tractors and machines on the remaining holdings to supplement animal power source. But many people are of the opinion that Indian agriculture cannot be fully mechanized. Only the improved animal-drawn implements should be introduced.

It is felt that

1. There is a surplus of agricultural labour in India.
2. There are enough draft animals available in the country to do the farm work effectively.
3. The size of farm holdings of the majority of the Indian farmers is too small to justify the use of a tractor on their farms.
4. The investing capacity, of the farmers is too poor to buy a tractor and tractor-drawn implements.
5. The technical know-how of the people in the country is low.
6. In the absence of suitable farm road system, the tractor and tractor-drawn machines cannot be effectively utilized under the present conditions.
7. It will not be possible to increase the yield by using mechanical power.
8. Mechanization will not result in lowering the cost of production.
9. It will not be possible to mechanize every bit of farm operation.
10. A large labour force will get displaced from agriculture.

Tractor - classification and different type of tractors and systems

Tractor is a self-propelled power unit having wheels or tracks for operating agricultural implements and machines including trailers. Tractor engine is used as a prime mover for active tools and stationary farm machinery through power-take off (PTO) or belt pulley.

Tractors can be classified into three classes on the basis of structural design

1. Wheel tractor
2. crawler tractor
3. walking type tractor

1. Wheel tractor

Tractors having three or four pneumatic wheels are called wheel tractors. Four wheel tractors are popular everywhere. On the basis of available power, these have been classified as

a. Small tractors – 15 to 25 hp.
b. Medium tractors – 25 to 45 hp.
c. Large tractors – more than 45 hp.

Three wheel tractor

Four wheel tractor

2. **Crawler tractor**

This type is also called Track type tractor or Chain type tractor. In such tractors , there is endless chain or track in place of pneumatic wheels

Crawler tractors

3. Power tiller

Power tiller is a walking type tractor. This tractor is usually fitted with two wheels only. The direction of travel and its controls for field operation is performed by the operator, walking behind the tractor

Power tillers

Classification of wheel tractors

On the basis of purpose, wheeled tractors are classified into three groups

a. General purpose tractor

b. Row crop tractor

c. Special purpose tractor

a) General purpose tractor

It is used for major farm operations such as ploughing, sowing, harvesting and transporting works. Such tractors have i) low ground clearance ii)Increased engine power iii) good adhesion and iv) wide tyres


General purpose tractors

b) Row crop tractors

It is used for row crop cultivation. Such tractor is provided with replaceable driving wheels of different tread widths. It has high ground clearance to save damage of crops. Wide wheel track can be adjusted to suit inter row distance


Row crop tractors

c) Special purpose tractor

It is used for definite jobs like cotton fields, marshy lands, hill sides, garden etc. special designs are there for special purpose tractor.

Eg. a) Tractor with winch unit b) multi drive tractor c) tractor for golf grounds etc.

Tractor with winch unit

Multi drive tractors

Tractor for golf grounds

CONTROL BOARD OR DASH BOARD OF A TRACTOR

The control board of a tractor generally consists of: (1) Main switch (2) Throttle lever (3) Decompression lever (4) Hour meter (5) Light switch (6) Horn button (7) Battery charging indicator (8) Oil pressure indicator and (9) Water temperature gauge.

Some of the most common gauges on a tractor include:

- **Engine speed indicator (tachometer):** This gauge measures the speed of the engine in revolutions per minute (RPM). The operator can use this information to avoid over-revving the engine and to ensure that the engine is operating at the correct speed for the task at hand.
- **Oil pressure indicator:** This gauge measures the pressure of the oil circulating in the engine. Low oil pressure can indicate a problem with the lubrication system, which could lead to engine damage.

- **Engine temperature indicator:** This gauge measures the temperature of the engine coolant. High engine temperature can also lead to engine damage, so it is important for the operator to monitor this gauge closely.
- **Fuel gauge**: This gauge indicates the amount of fuel remaining in the tank. The operator can use this information to avoid running out of fuel while operating the tractor.
- **Transmission temperature indicator:** This gauge measures the temperature of the transmission fluid. High transmission temperature can indicate a problem with the transmission, which could lead to transmission failure.
- **Hydraulic system oil level indicator:** This gauge indicates the level of hydraulic oil in the hydraulic system. Low hydraulic oil level can indicate a leak or other problem with the hydraulic system.

CHAPTER- 2

POWER TRANSMISSION SYSTEM

Transmission is a speed reducing mechanism, equipped with several gears (Fig. 1). It may be called a sequence of gears and shafts, through which the engine power is transmitted to the tractor wheels. The system consists of various devices that cause forward and backward movement of tractor to suit different field condition. The complete path of power from the engine to the wheels is called power train.

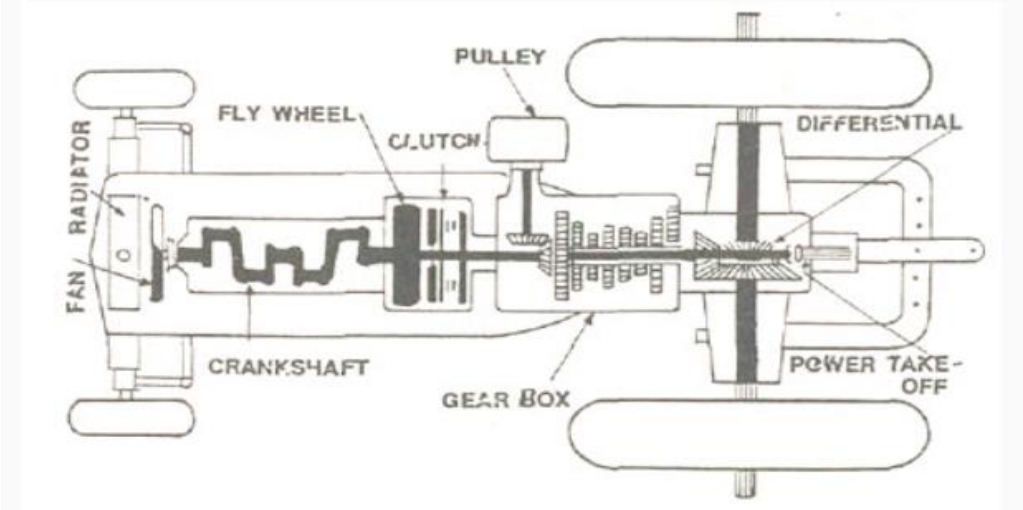


Fig.1

Functions and various components of power train

Function of power transmission system:

(i) to transmit power from the engine to the rear wheels of the tractor,
(ii) to make reduced speed available, to rear wheels of the tractor,
(iii) to alter the ratio of wheel speed and engine speed in order to suit the field conditions and
(iv) to transmit power through right angle drive, because the crankshaft and rear axle are normally at right angles to each other.

The power transmission system consists of: (a) Clutch (b) Transmission gears (c) Differential (d) Final drive (e) Rear axle (f) Rear wheels. Combination of all these components is responsible for transmission of power.

Clutch; functions of clutch, type of clutch (single plate, dual plate and multi plate clutch).

Clutch is a device, used to connect and disconnect the tractor engine from the transmission gears and drive wheels. Clutch transmits power by means of friction between driving members and driven members.

Necessity of clutch in a tractor:

Clutch in a tractor is essential for the following reasons:

(i) Engine needs cranking by any suitable device. For easy cranking, the engine is disconnected from the rest of the transmission unit by a suitable clutch. After starting the engine, the clutch is engaged to transmit power from the engine to the gearbox.

(ii) In order to change the gears, the gearbox must be kept free from the engine power, otherwise the gear teeth will be damaged and engagement of gear will not be perfect. This work is done by a clutch.

(iii) When the belt pulley of the tractor works in the field it needs to be stopped without stopping the engine. This is done by a clutch.

Essential features of a good clutch:

- It should have good ability of taking load without dragging and chattering.
- It should have higher capacity to transmit maximum power without slipping.
- Friction surface should be highly resistant to heat effect.
- The control by hand lever or pedal lever should be easy.

TYPES OF CLUTCH: (1) Friction clutch (2) Dog clutch (3) Fluid coupling.

FRICTION CLUTCH:

Friction clutch produces gripping action, by utilising the frictional force between two surfaces. These surfaces are pressed together to transmit power. While starting the engine, the clutch pedal is depressed. After the start of the engine, the clutch pedal is slowly released to increase the pressure box for onward transmission to the rear wheels. This pressure is obtained by a set of heavy springs, fitted together in housing. Engagement and disengagement of this type of clutch is very smooth due to larger surface area of friction members.

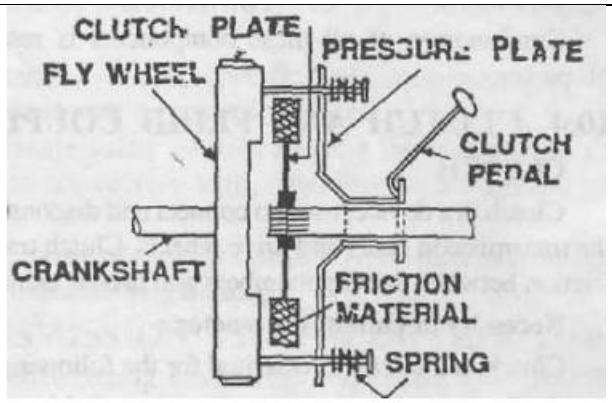


Fig. Single plate clutch

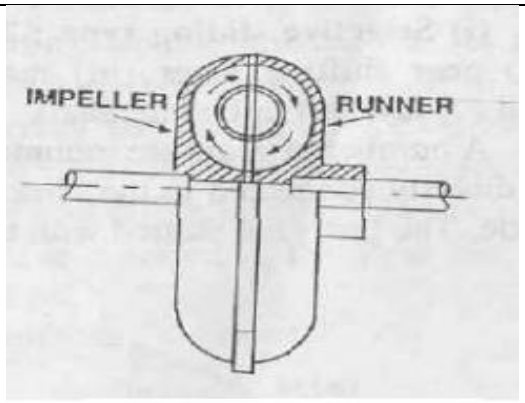


Fig. Fluid coupling

Main components of a Single Plate Axial Spring type friction clutch

Flywheel: It is connected to the engine crankshaft and is used to store the energy.

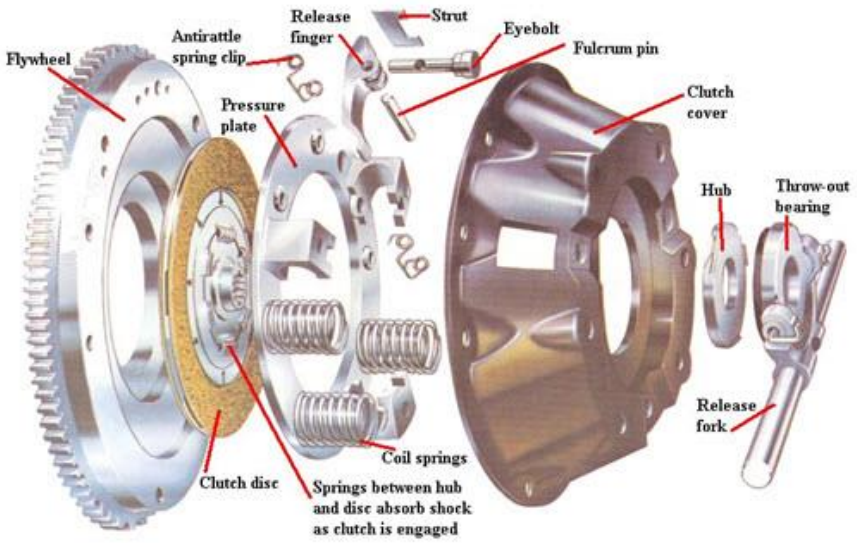
Clutch Plate: It consists of a steel disc with the centre splined. Frictional material is mounted (riveted) around the circumference of the steel disc.

Pressure Plate: The pressure plate pushes the clutch plate onto the flywheel due to spring pressure so that the clutch plate on one side and the flywheel on the other.

Axial Springs: Axial springs provide the clamping force due to which the power can be transmitted from the flywheel to the clutch plate.

Clutch cover: It is not only covers the clutch components, but also provides motion from the flywheel to the pressure plate.

Clutch release system: It consists of those components which are required for engaging -disengaging the power transmission to the clutch plate.



Dog clutch:

It is a simple clutch having square jaws, which are used to drive a shaft in either direction. It is mostly used in power tillers.

A dog clutch is a type of clutch that couples two rotating shafts or other rotating components by engagement of interlocking teeth or dogs rather than by friction.

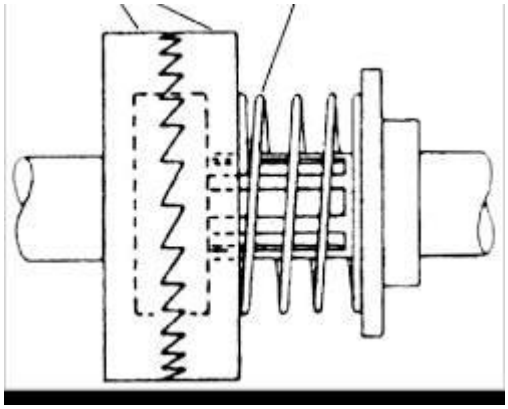


Fig. Dog Clutch

Fluid coupling:

Fluid coupling consists of a driving member and a driven member. An impeller with radial-vanes constitutes the driving member and runner with radial vanes constitutes the driven member. The enTYRE unit is housed in a suitable casing. A coupler is mounted on the engine crankshaft and is 3/4th filled with suitable oil. A spring loaded sealing ring is provided to make the driven shaft oil tight. At the rotation of the crankshaft, the oil is thrown out by centrifugal force from the centre to the outer edge of the impeller, increasing the velocity and the energy of the oil. It then enters the runner vanes at the outer portion and flows towards the centre, causing rotation to the runner unit. As long as impeller and runner rotate at different speeds, the oil continues to circulate uniformly but when the impeller and runner start running at same speed, the circulation of oil stops. The coupling does not increase the applied torque but only transmits the torque in a uniform manner.

The main features of fluid coupling are: (i) Absorption of shock and vibration (ii) Smooth starting and (ii) Easy operation.

TRANSMISSION GEARS AND TORQUE CONVERTER GEAR

A tractor engine runs at high speed, but the rear wheel of the tractor requires power at low speed and high torque. That's why it becomes essential to reduce the engine speed and increase the torque available at the rear wheels of the tractor because

$2 \pi NT/4500 = P$

Where T is torque in kg-m and N is rev/min.

If the engine hp is constant, it is obvious that for higher torque at wheels, low speed is required and vice versa. So the gearbox is fitted between engine and rear wheel for variable torque and speed. This is done by suitable design of gear and shafts (Fig. 4). Speed varies according lo the field requirements and so a number of gear ratios are provided to suit the varying conditions. Gears are usually made of alloy steel. As the tractor has to transmit heavy torque all the time,-best quality lubricants free from sediments, grit, alkali and moisture, is used for lubrication purpose. SAE 90 oil is generally recommended for gearbox.

Gear box; function and working of gear box, types of gear boxes (sliding, constant mesh and synchromesh gears).

While moving the vehicle/tractor in the field or for transportation purposes, there is a large variation of torque and speed requirements. The requirements of a transmission system are as listed below:

- To reduce the rpm from the engine before it reaches the wheel.
- To change the direction to rotation by providing a reverse gear.
- To provide the required torque or speed depending on the field requirement or the operation being performed.
- To provide a neutral position, where-in the power from the engine can be disconnected from the power train.

In case of automobiles, the starting torque is higher as compared to the cruising torque. The requirement of torque and speed keeps on changing with the driving conditions. In case of tractors this requirement and combination of speed and torque changes with the operation being performed. Providing for these requirements helps in running the engine and the machine for best tractor-machine system efficiency and returns the best fuel efficiency.

The speed ratios provided by tractor transmissions can be arbitrarily divided into low speed gears and transport gears. Low speed gears provide high torque at low speeds. These are required for performing operations such as tillage, crop planting and harvesting operations. The transport gears are used specifically for transportation purposes specially when there are good road conditions.

The gear box can also be classified based on arrangement of shafts between which the gears are mounted:

i) Parallel shafts (spur gears, helical gears, etc.)

ii) Shafts at an angle in the same plane (bevel gears)

iii) Shaft an angle not in the same plane (worm, hypoid gears)

Types of gearbox

The automobile transmission gear boxes can be classified into different categories based on the method in which the gears are meshed and speed ratios selected. Gear boxes used for transmission systems are classified into:

1. Sliding Mesh Gear Box
2. Constant Mesh Gear Box
3. Synchromesh Gear Box

The main components of the gear box are:

- ✓ Gear Box housing
- ✓ Gear shafts
- ✓ Gears
- ✓ Bearings

The gear box housing is the outer casing, usually made of cast iron that houses the various shafts and gears inside. It also contains the gear box oil (SAE 90) for lubrication of the gears.

There are three types of shafts inside the gear box:

- ❖ Input shaft (also called primary shaft or clutch shaft)
- ❖ Counter shaft (also called lay shaft or auxiliary shaft)
- ❖ Main shaft (also called secondary shaft or out shaft)

The gears on these respective shafts are called by the name of the shaft i.e. input pinion, counter shaft gear, main shaft gear.

On the primary shaft is only one gear (helical type). The primary shaft takes the rotational power from the clutch. The clutch plate is mounted on one end of this shaft, the one side which is splined. The helical gear on the primary shaft is inside the gear box housing and is meshed to another helical gear on the counter shaft. All the gears on the counter shaft are fixed to the counter shaft and rotate along with the shaft.

While construction and working of primary and counter shafts in case of all the three types of gear boxes is similar, the construction and working of the main shaft gears. The main shaft is splined, but the main shaft gears sit on the main shaft in different ways depending on which gear box these are on. The construction and working of the gear boxes is described hereunder:

Sliding Mesh Gear Box

This is the oldest and the simplest of automotive gear boxes. As the name suggests, the selected main shaft gear is slid over the main shaft to mesh with corresponding gear on the counter shaft. While the main shaft is splined, the main shaft gears are splined from inside, such that there is a positive motion between the main shaft and the main shaft gears.

At any given time, only one set (pair) of main shaft and countershaft gear are in mesh with each other. In case two pairs get meshed, they will tend to rotate the main shaft at different speeds, leading to breakage of either the main shaft or the meshed gears.

When a particular gear is to be meshed, it is slid over the main shaft by its collar and is made to mesh with the corresponding counter shaft gear.

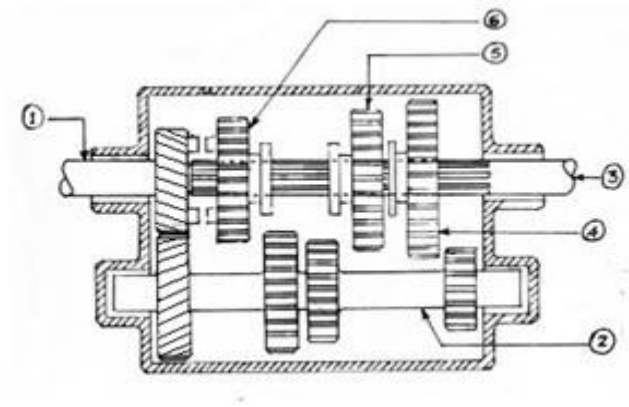


Fig. shows the various components of a sliding mesh gear box.

In, Fig. Cross-sectional view of a Sliding Mesh Gear Box

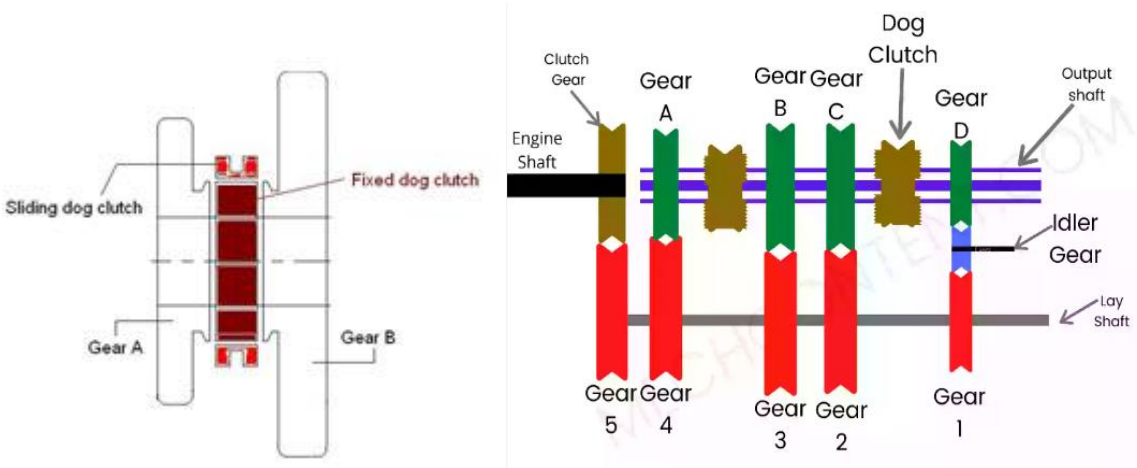
1. Input drive gear
2. Counter shaft
3. Main shaft
4. Ist gear
5. IInd gear
6. IIIrd gear

The gears 4, 5 and 6 on the main shaft can be slid to mesh with the corresponding gears on the counter shaft. The gear 4 is 1st gear, gear 5 is 2nd gear and gear 6 is the 3rd gear. For the 4th gear, the primary and the secondary shafts are coupled together implying that there is no speed reduction at the gear box in the 4th gear.

During the neutral position, none of the main shaft gears are engaged to the counter shaft gears. Depending on the speed-torque requirement, the gears of main shaft is slid to mesh with the respective gear on the counter shaft.

Constant Mesh Gear Box

In case of constant mesh type of gear box all the gears of main shaft are constantly meshed to the corresponding gears on the counter shaft as shown in the figure below:



Similar to the sliding mesh gear box, the main shaft is splined in this case too. But since all the gears on the main shaft are meshed, these are free to rotate on the splined main shaft. To transmit power an arrangement of fixed dog clutch and sliding dog clutch is used.

As mentioned before, the main shaft gears are free to rotate on the main shaft. The fixed dog clutch, placed between two gears is splined from inside in such a way that its rotation is associated with the main shaft i.e. when the fixed dog clutch rotates, the main shaft rotates and vice versa.

During the neutral position, the sliding dog sits on the fixed dog clutch (as shown in Fig). Now when the gear A is to be meshed, the sliding dog clutch is moved to the left so that it locks the movement of the gear to that of the fixed dog clutch. Now the gear is meshed to the corresponding gear of the counter shaft. When this gear gets locked to the fixed dog clutch, the power from the gear is transmitted to the main shaft through the fixed dog clutch. All this while the other gears continue to rotate freely on the main shaft without any interference.

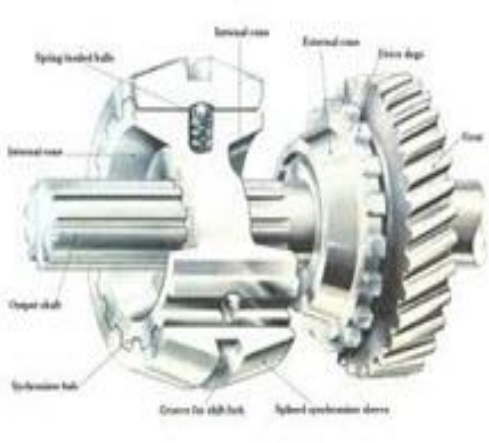
In this case all the gears on the main shaft are meshed to the corresponding gears of the counter shaft. These gears are of helical type. The advantages the helical gears offer as compared to spur gears is that in case of helical gears the contact starts with a point contact thus there is less noise and it also has more area of the gear teeth in contact leading to stronger gears and higher amount of torque that can be transmitted.

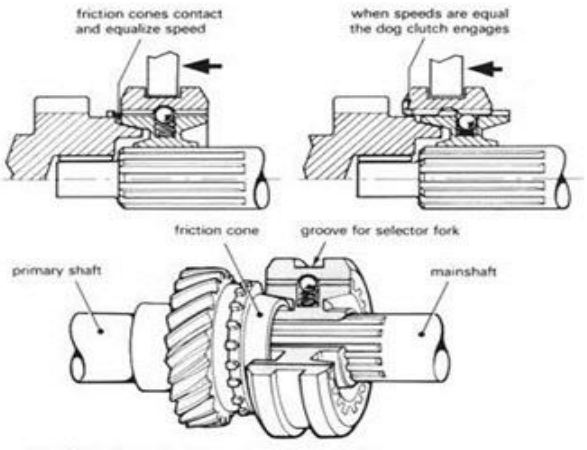
While engaging the gears from neutral position, when the clutch is engaged, all the gears on main and counter shafts are rotating, but all the sliding dog clutches are in neutral position. Now to engage the gear, the clutch is disengaged, but the gears are still rotating because of their momentum, the selected sliding dog clutch is moved as per requirement towards the gear that is to be engaged. As the relative motion between the gear and the dog clutches reduces, the sliding dog clutch engages with the selected gear and the clutch can be gradually engaged.

In case of the constant mesh gear box, the clutch has to be pressed twice while moving from one gear to another. This is done in such a way that the clutch is pressed once for moving from the gear to neutral position and the second time for moving from neutral to other gear. This process of pressing the clutch twice is called double de-clutching.

Synchromesh Gear Box

Synchromesh is advancement over the constant mesh gear box. A synchronizing unit is provided to assisting in the gear changing.





The fundamental principle of a synchromesh gearbox is to establish frictional contact between the gear and synchronizer before the actual engagement occurs. This pre-engagement friction allows the gear's rotational speed to be synchronised with the

corresponding speed of the synchronizer. Only when the speeds are harmonised the gear is fully engaged, ensuring smooth and seamless gear shifts.

Transmissions serve the purpose of providing torque and speed as needed for different driving conditions.

Low gears offer low speeds but high torque, ideal for situations requiring more power, such as climbing steep slopes or towing heavy loads.

High gears, on the other hand, provide high speeds but lower torque, suitable for cruising at higher velocities on level roads.

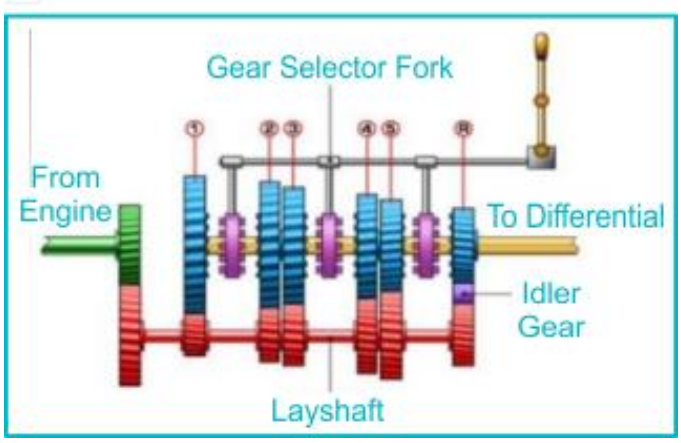


Fig. Working of Synchromesh Gearbox

Advantages of Synchromesh Gearbox:

The advantages of Synchromesh Gearbox include:

De-clutching Not Required: Unlike constant mesh gearboxes, the synchromesh gearbox eliminates the need for de-clutching during gear changes, simplifying the driving experience.

Reduced Noise: The use of helical gears with teeth cut at a specific angle contributes to quieter gear operation, minimising noise compared to other gear types.

Smooth Gear Transitions: The presence of a synchronizer device enables smooth and seamless gear shifts in the synchromesh gearbox, ensuring a quiet transition between gears.

No Loss of Torque: The presence of synchronizers ensures that there is no loss of torque during transmission, resulting in improved power transmission efficiency.

Enhanced Power Transmission: With minimal torque loss, the synchromesh gearbox can deliver more effective power transmission, enhancing the overall vehicle performance.

Reduced Vibration: The design and operation of the synchromesh gearbox result in lower gearbox vibration levels, leading to a smoother and more comfortable driving experience.

Overcoming Clattering and Grinding: The synchromesh gearbox successfully overcomes the clattering and grinding issues often encountered in constant mesh gearboxes, further enhancing gear engagement smoothness.

Disadvantages of Synchromesh Gearbox:

Some of the major disadvantages of Synchromesh Gearbox are:

Higher Manufacturing Cost: The Synchromesh gearbox tends to be more expensive due to the intricate and delicate nature of its components.

Complexity and Bulky Design: The system's increased complexity and bulkiness can make servicing and maintenance more challenging compared to simpler transmission systems.

Space Requirement: Synchromesh gearboxes demand a larger amount of space, which can be a constraint in certain vehicle designs.

Potential for Damage: Improper engagement of gears in the synchromesh gearbox can lead to gear damage, affecting the overall performance and longevity of the transmission.

Limited Load Handling: The synchromesh gearbox may not be suitable for handling very high loads, as higher loads can cause the teeth in contact to break.

Selective Synchronization: Some vehicles employ synchronizer systems only on higher gears, utilising constant mesh gears for lower and reverse gears to reduce manufacturing costs.

Differential and differential lock; function and constructional details

Differentials and locking differentials are both used in vehicles to help distribute power to the wheels. A differential is a mechanical device that allows wheels on the same axle to rotate at different speeds. This is important when a vehicle is turning, as the inside wheel needs to rotate at a slower speed than the outside wheel in order to maintain traction. A locking differential, also known as a limited-slip differential, is a type of differential that locks the wheels together when traction is lost. This allows the wheels to rotate at the same speed, providing more stability and control to the vehicle. Locking differentials are typically used in off-road vehicles, as they provide better traction on rough terrain.

In summary, a differential distributes power to the wheels, allowing them to rotate at different speeds and a locking differential locks the wheels together to provide more stability and control to the vehicle.

Working Principle of Differential system:

When an automobile travels around a corner, the distance traveled by the outside wheels is greater than that traveled by the inside wheels. If the wheels are mounted on dead axles so that they turn independently of each other, like the front wheels of an ordinary passenger vehicle, they will turn at different speeds to compensate for the difference in travel. But, if the wheels are driven positively by the engine, a device is necessary which will permit them to revolve at different speeds without interfering with the propulsion system. To accomplish this purpose a system of gears called the differential is provided.

The driving axle is one of the cross members which supports the load of the tractor, and has the driving wheels at its ends. The driving axle consists of a housing, a differential, two axle shafts (half axles), and final drives (if required).

The differential is an important component of the driving axle. The main functions performed by the differential system are:

- Further reduces the rotations coming from the gear box before the same are passed on to the rear axles.
- Changes the direction of axis of rotation of the power by 90^{o} i.e. from being longitudinal to transverse direction.
- To distribute power equally to both the rear driving axles when the tractor is moving in straight ahead direction.
- To distribute the power as per requirement to the driving axles during turning i.e. more rotations are required by the outer wheel as compared to the inner wheel – during turns.

The main components of the differential (As shown in Fig.) are:

1. Input pinion gear
2. Crown wheel gear
3. Differential cage
4. Differential star
5. Differential axle (sun) gear

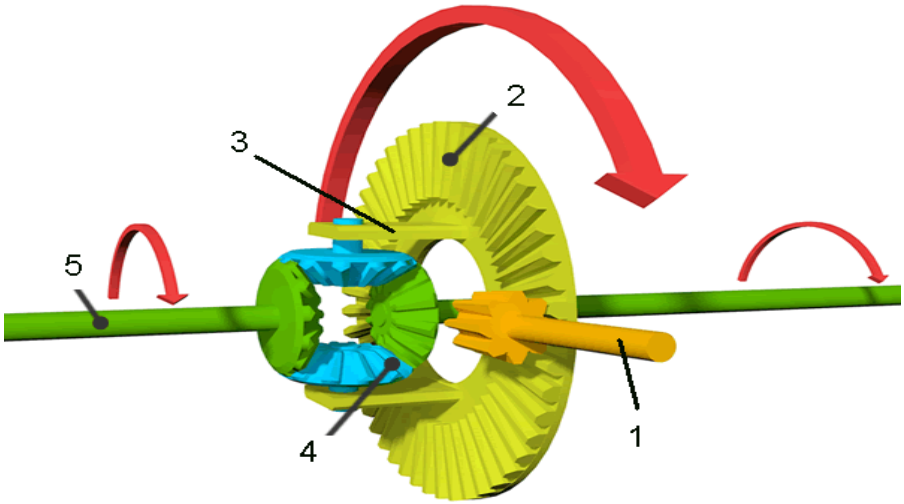


Fig. Differential Unit

Differential lock

Differential lock is a device to join both half axles of the tractor so that even if one wheel is under less resistance, the tractor comes out from the mud etc. as both wheels move with the same speed and apply equal traction.

Final drive

Final drive is a gear reduction unit in the power trains between the Differential and the Drive wheels. Final drive transmits the power finally to the rear axle and the wheels. The tractor rear wheels are not directly attached to the half shafts but the drive is taken through a pair of spur gears. Each half shaft terminates in a small gear which meshes with a large gear called Bull gear. The Bull gear is mounted on the shaft carrying the tractor rear wheel. The device for final speed reduction, suitable for tractor rear wheel is known as Final drive mechanism.

Power-take off shaft (PTO)

It is a part of tractor transmission system. It consists of a shaft, a shield and a cover. The shaft is externally splined to transmit torsional power to another machine. A rigid guard fitted on a tractor covers the power take-off shaft as a safety device. This guard is called power take-off shield.

Agricultural machines are coupled with this shaft at the rear part of the tractor. As per ASAE standard PTO speed is 540 ± 10 rpm when operating under load.

CHAPTER- 3
BRAKING SYSTEM

Brake System – necessity, working principle, functional components

❖ Brakes

The braking system is an important system in the tractors used to slow down or stop the tractor motion. It is also used to prevent the tractor from moving when it is stationary. During field operations it helps in taking sharp turns by applying differential brakes on the two rear wheels.

The brakes use the frictional force to reduce the motion of the wheels. Friction is used to convert the kinetic energy into heat.

The brake arrangement serves to intentionally offer resistance to the movement of the tractor. Most common are the friction brakes. These are essentially heat devices that change the kinetic energy of the moving vehicle into heat, by virtue of friction between a rotating component and a stationary component which are mechanically moved so that they come in contact with the rotating component. The stationary are lined with a hard wearing friction material. When this material is moved into contact with the rotating component, braking takes place.

Brake is used to stop or slow down the motion of a tractor. It is mounted on the driving axle and operated by two independent pedals. Each pedal can be operated independently to assist the turning of tractor during the fieldwork or locked together by means of a lock.

Principle of operation: Brake works on the principle of friction. When a moving clement is brought into contact with a stationary element, the motion of the moving element is affected. This is due to frictional force, which acts in opposite direction of the motion and converts the kinetic energy into heat energy.

Classification of brake: Brake can be classified as:

(1) Mechanical brake and

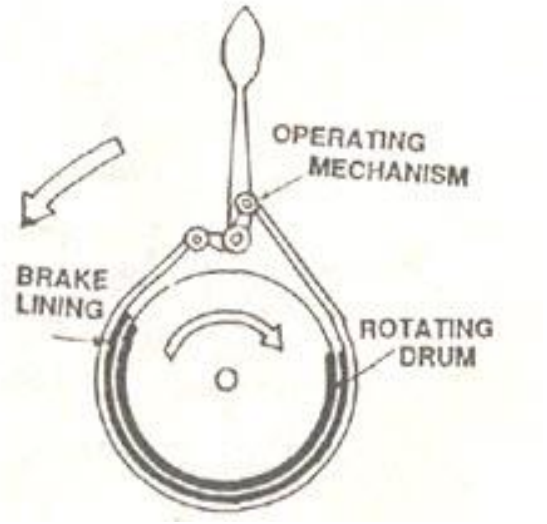
(2) Hydraulic brake.

Mechanical brake can be classified as:

(a) Internal expanding shoe type

(b) External contracting shoe type and

(c) Disc type.



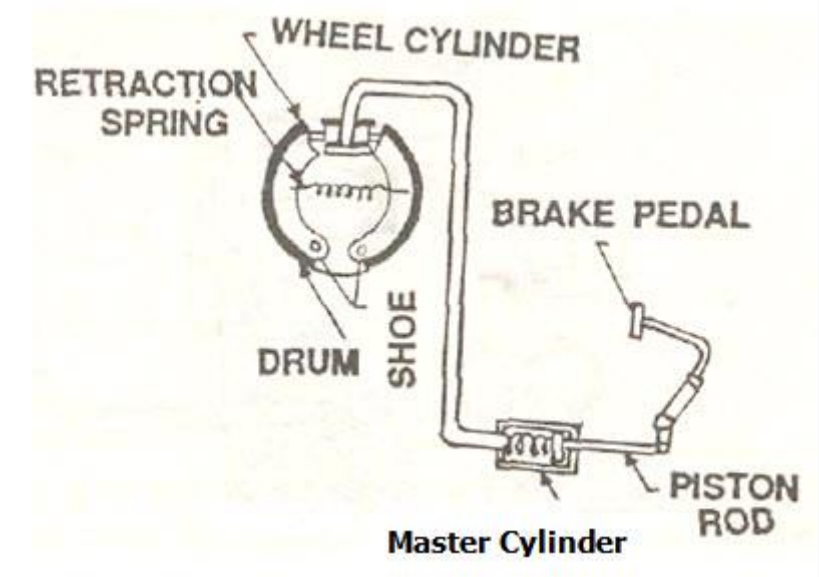
Internal expanding shoe type: Two brake shoes made of frictional material fitted on the inside of the brake drum are held away from the drum by means of springs. One end of each shoe is fulcrum whereas the other is free to move by the action of a cam which in turn applies

force on the shoes. The movement of the cam is caused by the brake pedal through the linkage. The drum is mounted on the rear axle whereas the shoe assembly is stationary and mounted on the back plate.

External contracting shoe type: This type of brake system is normally available on crawler tractors. The brake band directly surrounds the drum mounted on the drive axle. When the pedal is depressed, the band tightens the drum

Disc brake: Two actuating discs have holes drilled in each disc in which steel balls are placed. When the brake pedal is depressed, the links help to move the two discs in opposite directions. This brings the steel balls to shallow part of the holes drilled in the disc. As a result, the two discs are expanded and braking discs are pressed in between the discs and the stationary housing. The braking discs are directly mounted on the differential shaft, which ultimately transfers the traveling effect to the differential shaft.

Hydraulic brake: Hydraulic brake system is based on the principle of pascal's law. The brake fluid, which is usually a mixture of glycerin and alcohol, is filled in the master cylinder. When the pedal is depressed, the piston of the master cylinder is forced into the cylinder and the enTYRE system turns to a pressure system. Immediately, the piston of the wheel cylinder slides outward which moves the brake shoes to stop the rotating drum. When the pedal is released, the return spring of the master cylinder moves the piston back to its.



Braking Efficiency:

High braking efficiency is required as on many occasions the brakes are required to stop the vehicle in emergency. However higher brake efficiency not only leads to stopping in a shorter time, may also cause injury to the driver operator due to high decelerating forces and dislodging of loads in the trolley. Higher braking efficiency also causes rapid wear of the brakes and there is more risk of losing control of the vehicle. Braking efficiencies of the order of 50-80% enable to stop within reasonable distance. However the stopping distance varies with the type of road conditions and condition of the tyres.

Braking distance generally refers to the distance a vehicle will travel from the point when the brakes are fully applied to when it comes to a complete stop. It is primarily affected by the original speed of the vehicle and the coefficient of friction between the TYREs and

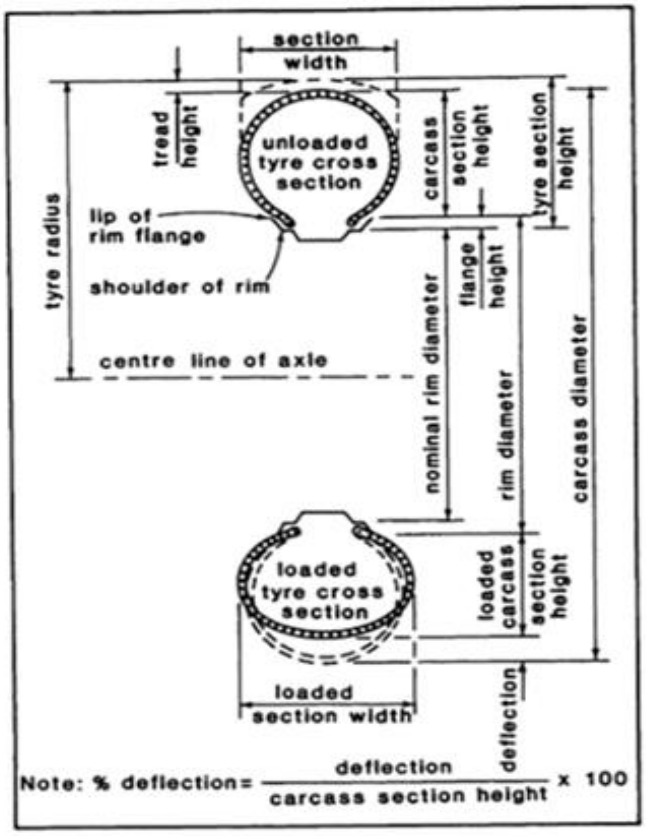
the road surface. Braking distance also includes the reaction time to when the driver feels the need to stop the vehicle and the response time.

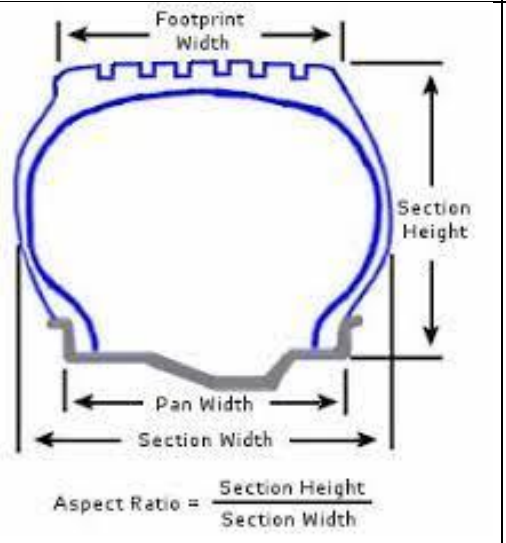
CHAPTER- 4

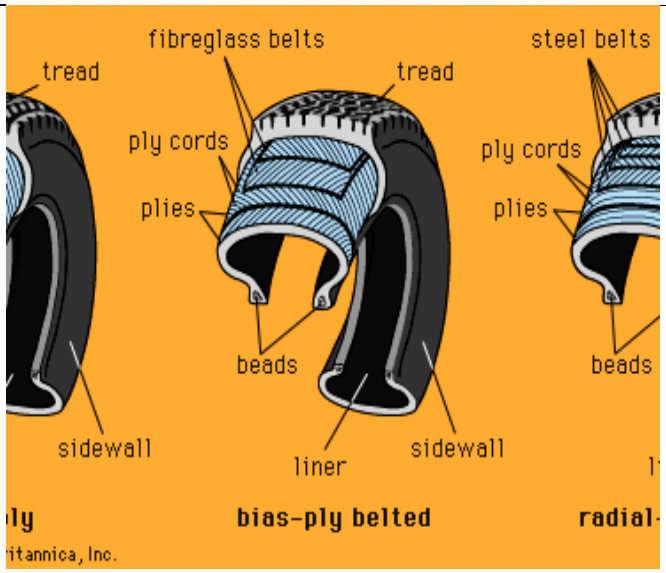
WHEELS AND TYRES OF TRACTORS

TYRE

A tyre forms a torus of a complex flexible reinforced composite material surrounding a steel hub and filled up with air under pressure. It has more or less expanded ribs on the rolling tread. The different types of torus shapes and construction are selected according to the tyre application. In general, a tyre is characterized by the tyre construction type, mounting data, ply rating and other dimensions.







TYRE FUNCTION

The agricultural tyre must perform the following functions:

- To support the vehicle and associated loads at some low level of ground pressure,
- To absorb shock loads and cushion the vehicle against minor surface irregularities,
- To provide traction (and braking),
- To provide for steering and directional stability,
- To resist the abrasive action of the various surfaces on which it is expected to operate.

CATEGORIES OF TYRE APPLICATIONS

The type of application (of tyres as traction elements) can be divided into the following four broad categories, each of which is comparatively unique.

1. In the construction field, as typified dam, waterway and highway projects which require movement of large quantities of earth and rock. In this type of service, speeds as high as 40 to 80 km h^{-1}, length of haul to 16 km, and size of loads and equipment to 75 m^3 capacity are generally expected.
2. In the logging, mining and petroleum industries – heavier units such as mobile cranes and self-contained pumps and power plants, are used. This demands tyre types with high floatation characteristics and load carrying capacities.
3. In military operations. In this field the various types of tyred vehicles are expected to operate over a great variety of surfaces in cross-country transport. Reliability is of particular importance.
4. In general transportation into newly developed areas without adequate highways or railways – such vehicles must have floatation and mobility capability under heavy loads, without the need for extensive preparation and maintenance of roads or tracks.

TYRE SIZES AND TYPES

The growth of off-road operations has brought about a great diversification in tyres to meet all service requirements.

1. Number of sizes. TYREs have become larger both in cross-section and in rim diameter. Larger tyres permit higher loads per tyre without sacrificing floatation.

2. Conventional vs wide base. Two types of tyre now exist namely, conventional and wide base. Without changing the rim diameter or tyre overall diameter, the cross-section width can be increased by using a wider rim. With the same tyre loading, inflation pressures on the wide base tyre can be reduced. The wider cross-section gives improved traction and floatation and the lower unit ground pressure can improve the resistance to damage from stones and other objects.

3. Low section-height TYREs. The wide base principle can be extended into low section-height TYREs. The low section-height shape makes possible a wider cross-section for improved floatation without increasing overall diameter or tyre weight, as would have been necessary if conventional tyre shapes had been maintained.

4. Single vs dual. Another application of low-section height principle is in the use of larger simple tyres to replace dual tyres. Although the change from dual tyres to on large single tyre reduces total ground contact area, experience has shown that floatation and mobility are improved without reduction in total load carrying capacity.

5. Tread pattern. All off highway operations do not need the same degree of traction. As a result, separate tread designs are used for different degrees of tractive effort.

TREAD

The important variables in relation to the tyres include:

(i) size (diameter and width) which determines their tractive capacity and rolling resistance.

(ii) strength, expressed in terms of ply rating, which in turn determines the pressure that can be used and hence the weight that the tyre can carry; this in turn also determines the tractive capacity and the rolling resistance.

(iii) tread pattern which, together with the surface characteristics, determines the engagement and / or contact with the surface.

The losses in power at the wheel / surface interface are often great, particularly on soft surfaces (ie, their efficiency is low), hence the power available at the tractor drawbar may be much less than the power of the engine. Hence the choice of the tyres and the weight on them is crucial in determining the overall performance of the tractor.

CHAPTER- 5
HYDRAULIC SYSTEM

Principle and Working of Hydraulic System

Hydraulics is the use of a liquid as a medium to transmit power from one point to another. It is based on Pascal's law, which states that pressure applied to a confined incompressible fluid is transmitted equally in all directions.

A basic hydraulic system consists of a pump, a reservoir, a control valve, and an actuator. The pump creates pressure in the fluid, which is then transmitted through the control valve to the actuator. The actuator converts the hydraulic pressure into mechanical force, which can be used to move objects.

Hydraulic systems are used in a wide variety of applications, including construction, manufacturing, agriculture, and transportation. They are particularly well-suited for applications where high forces and precise movements are required.

Various components of hydraulic system:

The hydraulic system of a tractor is a complex system that uses fluid power to operate various attachments. The system consists of a number of components, including:

- **Hydraulic pump**
  It converts the mechanical energy into hydraulic energy by forcing hydraulic fluid, under pressure, from the reservoir into the system. It may be called heart of the hydraulic system. The pumps used in the hydraulic circuit are generally of three types - piston type, gear type or vane type. A pump normally creates a partial vacuum, which causes the fluid to move through the pump and hence it keep on moving the fluid in the components.

- **Electric motor and coupling**
  These are used for running the hydraulic pump. An electric motor of suitable power rating is fitted as per the size of pump, pressure requirements etc. The pump and motor are connected with the help of a flexible coupling. The coupling absorbs the shocks and slight misalignment between the pump and the motor.

- **Oil sump or reservoir**
  It acts as a storehouse for the fluid and a heat dissipater. The hydraulic fluid stored in the sump is pumped into various components of the hydraulic system with the help of a pump. The capacity of the sump should be kept large, around three to four times the pump delivery, so that pump can move the fluid through the components continuously.

- **Strainer or filter**
  It filters the hydraulic oil circulating in the system. A strainer is required to have a filter in the system because the same oil is utilized again and again which makes the oil contaminated. The filters can be placed in the pump line, pressure line or return line. It collects the particles and prevents them from recirculation in the circuit.

- **Pressure gauge**

It is used for measuring pressure in the hydraulic system. System pressure is required to be measured at the outlet of the pump and hence a pressure gauge is mounted. It indicates the pressure in the lines which is an indicator of the safe working of the system. The pressure gauge may be of dial type or digital type.

- **Relief valve**
  It is used to protect the system from damage by releasing excess pressure in the system. Pressure relief valve limits the pressure of the circuit. As the system pressure exceeds the set operating pressure, the relief valve discharges oil directly to return line thereby protecting the system from any damage.

- **Hydraulic valves**
  These are provided to control pressure, direction and flow rate of the fluid in the hydraulic system.

- **Fluid lines**
  These transport the fluid to and from the pump through the hydraulic system. These lines can be rigid metal tubes, or flexible hose assemblies. Fluid lines can transport fluid under pressure or vacuum (suction).

- **Fluid**
  It can be almost any liquid. The most common hydraulic fluids contain specially compounded petroleum oils that lubricate and protect the system from corrosion.

- **Actuators**
  It convert hydraulic energy into mechanical energy to do work. A linear actuator gives force and motion outputs in a straight line. It is more commonly called a cylinder. A rotary actuator produces rotational motion like an electric motor.

The hydraulic system of a tractor is used to operate a wide variety of attachments, such as:

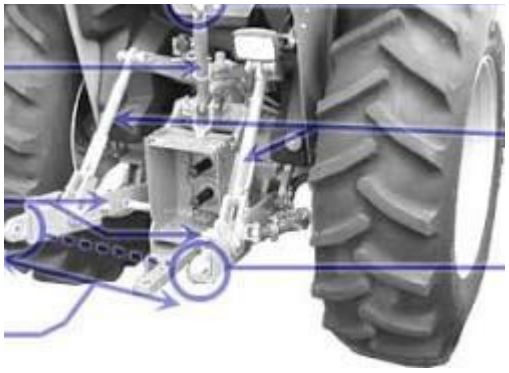
Three-point hitch: The three-point hitch is a system that allows the tractor to lift and lower attachments, such as plows, mowers, and backhoes.

- The hydraulic pump draws oil from the hydraulic tank and pumps it through the hydraulic control valve. The hydraulic control valve directs the flow of oil to the various attachments, such as the three-point hitch, front-end loader, or backhoe. The hydraulic cylinders convert the hydraulic pressure into mechanical force to operate the attachments. The hydraulic oil then returns to the hydraulic tank and the cycle begins again.
- The hydraulic system of a tractor is a complex system, but it is also a very reliable system. With proper maintenance, the hydraulic system can last for many years.

Various components of hitching system of tractor:

The hitching system of a tractor is a device that allows the tractor to attach to and operate various implements. It is made up of a number of components, including:

- Three-point hitch: The three-point hitch is the most common type of hitching system used on tractors. It consists of three arms: two lower arms and one top link. The lower arms are attached to the tractor's hydraulic system, which allows them to be raised and lowered. The top link is attached to the implement and helps to control its depth and angle.

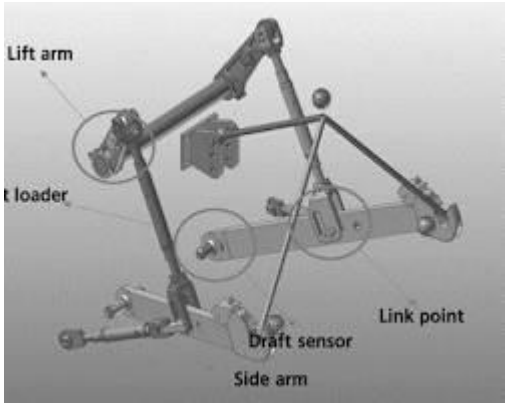


Three point hitch

- Drawbar: The drawbar is a simple hitching device that is attached to the rear of the tractor. It is used to pull implements, such as trailers and plows.
- Power take-off (PTO): The PTO is a shaft that is driven by the tractor's engine. It is used to power implements, such as mowers and hay balers.

Power takeoff (PTO)

- Quick hitch: The quick hitch is a device that allows the tractor to attach and detach implements quickly and easily. It is especially useful for implements that are used frequently.



Tractor hitching system diagram

The three-point hitch is the most versatile type of hitching system because it allows the tractor to attach to a wide variety of implements. The drawbar is simpler and less expensive, but it is not as versatile. The PTO is used to power implements that require a lot of power. The quick hitch is convenient, but it can be more expensive than a traditional three-point hitch.

The hitching system of a tractor is an important part of the tractor and is essential for operating many of the tractor's implements

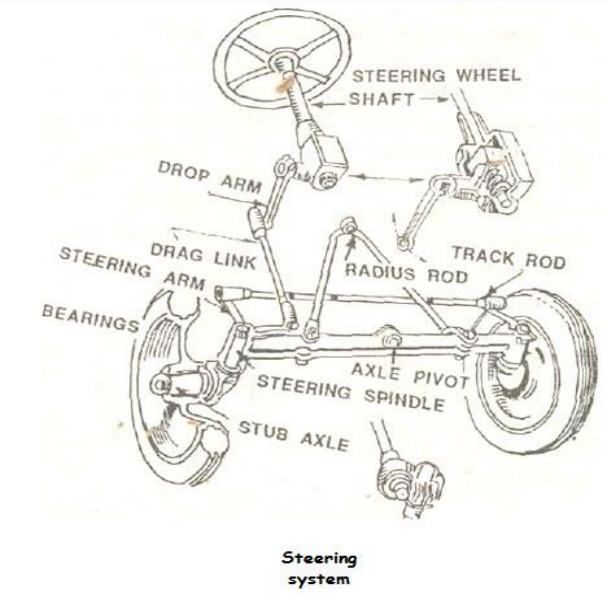
CHAPTER- 6
STEERING SYSTEM

- **Steering System**

The steering system is required to control the direction of motion of the vehicle (tractor in our case). This is done through a series of links used to convert the rotation of the steering wheel into change of angle of the axis of the steering wheels. Another function of the steering system is to provide directional stability. The motion of the vehicle being steered needs to become straight ahead when the force on the steering wheel is removed. The design of the steering system should be such that it should cause minimum wear of the tyres of the wheels.

The steering system can be classified into from wheel steering, rear wheel steering or all wheel steering.

The system, governing the angular movement of front wheels of a tractor is called steering system. This system steering wheel minimizes the efforts of the operator in turning the front wheel with the application of leverages. The different components of the system are:



Steering system

Components Steering System

- Steering wheel
- Steering shaft
- Steering gear
- Pitman arm (drop arm)
- Drag link
- Steering arm
- Tie rod and
- King pin.

When the operator turns the steering wheel, the motion is transmitted through the steering shaft to TYRE angular motion of the pitman arm, through a set of gears. The angular movement of the pitman arm is further transmitted to the steering arm through the drag link and tie rods. Steering arms are keyed to the respective kingpins which are integral part of the stub axle on which wheels are mounted. The movement of the steering arm affects the

angular movement of the front wheel. In another design, instead of one pitman arm and drag link, two pitman arms and drag links are used and the use of tie rod is avoided to connect both steering arms.

- **Steering system**

The function of a steering system is to convert the rotary movement of the steering wheel in driver's hand into the angular turn of the front wheels on road. Further, the steering system should provide mechanical advantage over front wheel steering knuckles, offering driver easy turning of front wheels with minimum effort in any desired direction.
There are two types of steering:
- Mechanical Steering
- Hydraulic Steering

The different types of steering gears are as follows:

1. Worm and sector steering gear.
2. Worm and roller steering gear.
3. Cam and double lever steering gear.
4. Worm and ball bearing nut steering gear.
5. Cam and roller steering gear.
6. Cam and peg steering gear.
7. Recirculating ball nut steering gear.
8. Rack and pinion steering gear.

- **Recirculating ball steering gear**

This is the most common steering gear in Indian tractors. In this the lower end of the steering column has a worm. A box type nut is clamped on this worm which has numerous ball bearings circulating between the worn and the nut. As the steering wheel on top of the steering column is turned, the nut moves up and down. This movement of the nut is sensed by the sector of the pitman which is connected to the nut. The movement of the nut is transferred into the rotational motion of the pitman. Drop arms are mounted on this pitman shafts. The blow-up figure of a recirculating ball steering box is as shown in Fig. 25.1.

- **Worm and Roller Type Steering Box**

In case of worm and roller steering, the worm at the lower end of the steering column is in the form of a cam. There is a roller which follows the shape of the worm. The roller is a part of the pitman. As the roller follows the cam when the steering column is turned, the motion is transferred to the pitman and to the drop arms. An exploded view of the worm and nut steering is given in Fig.25.2.

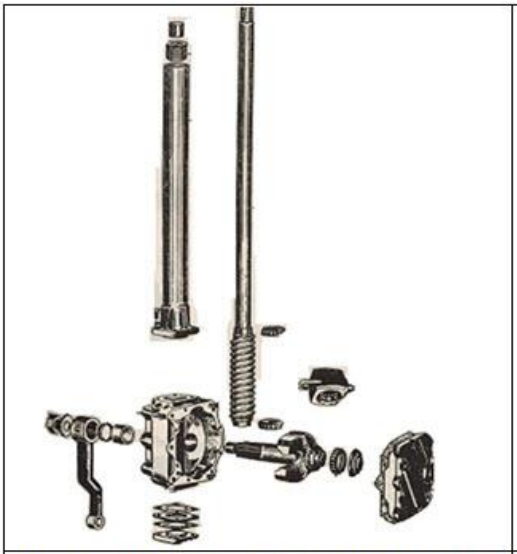


Fig 25.1 Blow-up of a Recirculating Ball Steering Box

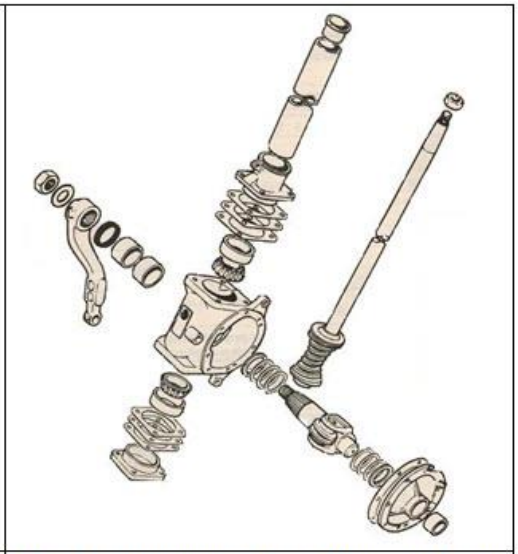


Fig 25.2 Blow-up of a Worm and Nut Steering Box

- **Worm and Sector Type Steering Box**

In this type of steering box, the steering worm of the steering column rotates a steering gear sector which is meshed with the worm. The gear sector in turn rotates the pitman on which it is mounted. The pitman is further connected to the steering linkage for steering the wheels. The Fig 25.3 shows the method in which the worm and sector steering is used to convert the rotation of steering column into rotation of pitman.

- **Rack and Pinion Type Steering Box**

In a rack and **pinion steering gear, a pinion** is attached at the end of the **steering shaft**. When the steering wheel is turned, the pinion gear spins, moving the rack – left or right, depending on which way the steering is turned. The rack forms the part of the tie rod with steering spindle at its ends which push or pull the steering links for steering the wheels. Fig 25.4 shows the arrangement for a rack and pinion steering box.

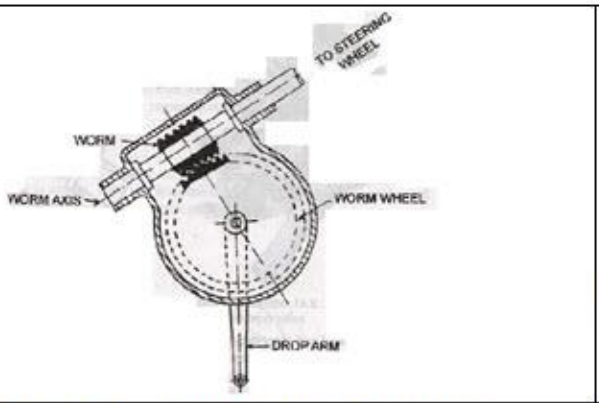


Fig 25.3 Worm and Sector Steering Box

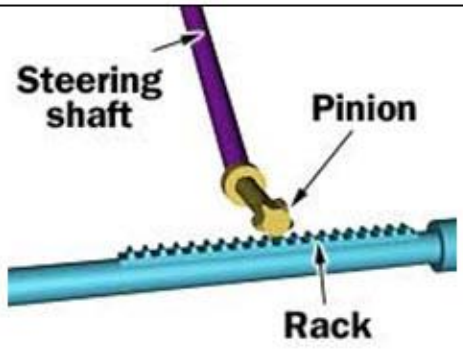


Fig 25.4 Rack and Pinion Steering Box

Note: The recirculating ball mechanism has the advantage of a much greater mechanical advantage, so that it was found on heavier vehicles while the rack and pinion was originally limited to smaller and lighter ones.

- **Tractor tyre and front axle**

The tyres are available in many sizes with the ply ratings as 4, 6 or 8. The ply rating of tyres indicates the comparative strength of tyres. The higher the rating, the stronger are the tyres. The tyres size 12—38 means, that the sectional diameter of tyres is 12" and it is mounted on a rim of 38" diameter. The inflation pressure in the rear wheels of the tractor varies between **0.8 to 1.5 kg/cm^2**. The inflation pressure of the front wheel varies from **1.5 to 2.5 kg/cm^2**. Useful life of the pneumatic tyres under normal operating condition may be about 6000 working hours for drawbar work.

- **Front axle and steering mechanism**

Front Axle

The front axles are generally dead axles. The front wheel hubs rotate on anti-friction bearing of tapered - roller type on the steering spindle which are an integral part of steering knuckle. To permit the wheels to be turned by the steering gear, the steering spindle and steering knuckle assemblies are hinged at the end of the axle. The pin that forms the pivot of this hinge is known as Kingpin or steering knuckle pin.

FRONT WHEEL ALIGNMENT

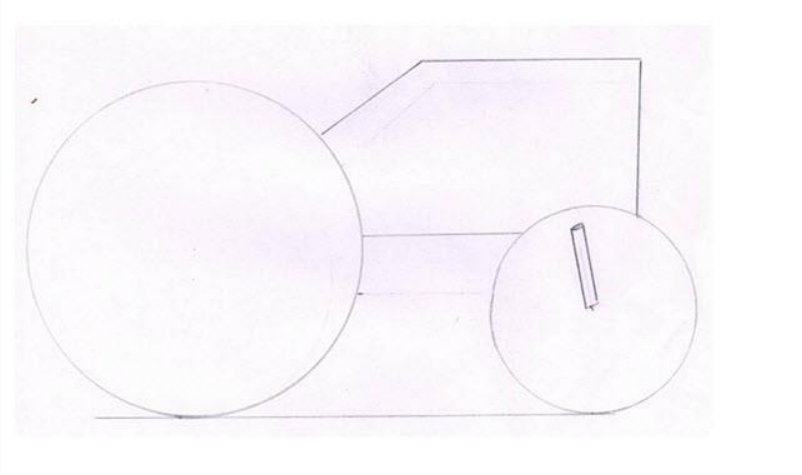
The front wheels must be in correct alignment in order to ensure easy steering, to give directional stability of the vehicle and to minimize tyre wear. Front wheel alignment is obtained through accurately setting of the following factors:

- Caster
- Camber
- Kingpin inclination
- Toe-in
- Toe-out

CASTER

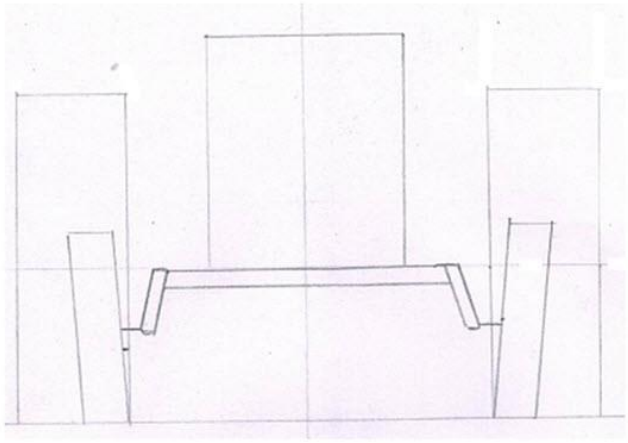
Caster angle is the tilt of the kingpin or ball joint centre line from the vertical towards either the front (negative caster) or rear (positive caster) of the vehicle.

The caster angle produces a trailing effect and hence gives the directional stability. In correct caster can produce difficulties like hard steering, pulling to one side when brakes are applied. The caster angle ranges from 2-8° negative.



CAMBER

Camber angle is the inclination between the centre line of the TYRE and the vertical line. The outward inclination is called positive camber and the inward inclination is the negative camber. The purpose of the camber is to prevent the top of wheels from tilting inward much due to excessive load or play in the king-pin and wheel bearing. Unequal camber in the wheels causes the vehicles to roll in the direction of wheel having the greater camber which upsets directional stability and tends to scuff the tread on the opposite TYRE, excessive camber prevents the TYRE from having correct contact with the road which causes it to wear only on the side directly beneath the load.
Camber angle is less than 1 degree.



KING-PIN INCLINATION
King-pin inclination is the inward tilt of the king-pin or ball joint centre line from the vertical. King-pin inclination in combination with camber provides directional stability. whereas the king-pin inclination and camber combine to give centre-point steering of the TYRE on the road and to bring upward thrust on the stub axle more nearly through the centre of the king-pin. The combined camber angle and king-pin inclination is called the included angle.
King-pin inclination ranges from 4-8°.

TOE-IN
Front wheels are usually drawn in slightly in front so that the distance between the back-ends (y) in slightly more than the distance between front-ends (x). The different between these distances is called toe in. Wheels are toed-in to offset the tendency for them to roll outward due to camber and to play in the steering linkage.
Toe-in is usually 2-4 mm.

TOE-OUT
When a vehicle takes a turn, the inside wheel moves faster than the outer wheel because the former has to negotiate an area with shorter radius than the latter. This action causes the wheels to out-out on turns because of difference in their turning angles.
Importance of wheel alignment

1. Improve Handling: - This helps in controlling the vehicle. Improper handling can be due to vehicle pulling on one side, vibration of the steering wheel.

2. Improves tyre life and performance: - Proper rolling tyre contact on road and prevention of slipping of the tyres due to improper alignment results in better tyre life.

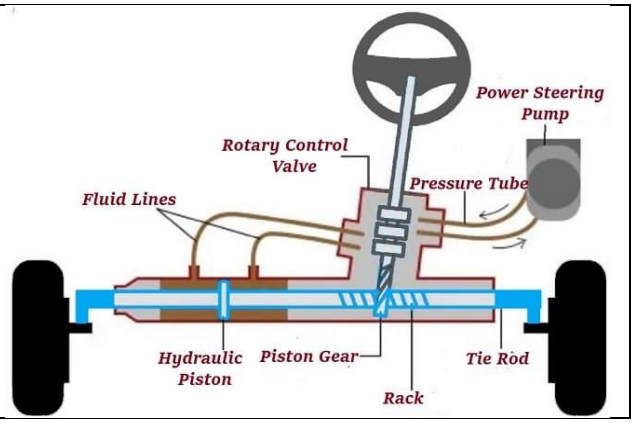
3. Helps in identifying problems: - Improper alignment could be a symptom of something wrong in the vehicle. A check on this can lead to correction in the fault in the vehicle.

4. Ensures Safety: - By keeping the system in order by removing the defective parts, enhances the vehicle systems, especially the suspension system, leading to better safety.

5. Improves fuel efficiency: - By enhancing the performance of various systems, leads to better fuel efficiency from the vehicle.

- **HYDRAULIC POWER STEERING**

Hydraulic power steering have a few additional parts to supply the extra power.

a. Hydraulic fluid b. Steering fluid reservoir c. Steering pump d. Rotary Valve e. Hydraulic Chamber	

Tractors having 30 KW or more power generally will have power steering. This is based on two basic fluid power types: There are

- Hydro mechanical systems

- Full hydraulic systems, commonly called hydrostatic power steering

- **Hydro-mechanical systems**

The term "hydrostatic" means those systems requiring no mechanical linkage between the driver's steering wheel and the steered wheels. In this system fluid under pressure is used not only power the load but also to provide hydraulic feedback from load and to transmit manual effort to the load when the power source is unavailable. The two most important advantages of the hydrostatic system are

- Flexibility of installation

- Lower cost

The most distinguishing feature common to hydrostatic steering systems is the use of a positive displacement flow metering or measuring device coupled to the steering wheel shaft. Hydrostatic systems can be categorized by the manner in which this metering device operates in the control loop. At least four basic types can be identified as given below:-

TYPE-1

The metering unit is mechanically linked to steering shaft and control value and is hydraulically connected in series to the actuator. It provides the remote monitoring of actuator position at the control value location, known as position feedback. an input error between the steering shaft and the metering unit is measured and translated into control value displacement by suitable mechanical means. The subsequent response of the actuator - metering unit to the directed flow cancels the error, thus returning the control value to the null position.

Type-2

The metering unit is rigidly coupled to the steering shaft and hydraulically connected in series with actuator, but in parallel with the control value pilot chambers. Here the metering unit functions as a transducer to convert steering wheel rotation and input torque into flow and pressure to displace the control value. The resulting flow of high pressure oil again passes through the metering unit before entering the actuator. The incremental activator motion, which continues after the steering wheel stops, hydraulically recenters the control value.

TYPE-3

The metering unit is mechanically linked to the steering shaft and control value as in type 1 but is hydraulically connected to a separate feedback displacement device, which in turn is linked to the output motion. This permits the control circuit to be isolated from the power circuit.

TYPE-4

The metering unit is rigidly attached to the steering shaft and hydraulically connected to the control value as in Type 2, but it is hydraulically coupled to a separate feedback device as in type 3. This is a simpler, lower cost arrangement than type 3 but introduces an operational factor.

Parameters that influence power requirements are:

1. Tyre loading
2. Road surface and soil conditions
3. Tyre inflation pressure
4. Tyre sizes and tread patterns
5. King-pin inclination
6. Caster angle
7. Camber angle
8. King-pin offset
9. Toe-in and toe-out
10. Tread setting
11. Travel speed
12. Steering rates
13. System efficiency
14. Front end type
15. Tractive and braking force
16. Chassis type

- **Components of power steering**

a. Hydraulic fluid

A hydraulic fluid or hydraulic liquid is the medium by which power is transferred in hydraulic machinery. Common hydraulic fluids are based on mineral oil. Power steering fluid is a sub type of hydraulic fluid. Most are mineral oil or silicone based fluids, while some use automatic transmission fluid, made from synthetic base oil. Use of the wrong type of fluid can lead to failure of the power steering pump.

b. Steering fluid reservoir

It holds the fluid, and supplies them to the steering pump through rubber hoses.

c. Steering pump

When tractor's engine is running, the engine belt turns in a loop and that also turns the steering pump. With that, the pump pulls the steering fluid from the steering fluid reservoir and pressurizes them. We put low pressure steering fluid in, and high pressure steering fluid comes out of the other end. This high pressure steering fluid then leaves the steering pump, through the steering hoses and into the steering rack, specifically into the rotary valve.

d. Rotary Valve

A rotary valve is a highly sensitive metal casing with strategically placed holes that redirects the steering fluid either back to the steering pump or into the steering rack. If the steering wheel is in its original position, the rotary valve redirects the steering fluid back to the steering pump and nothing happens. The cycle of steering fluid moving from reservoir to pump and to rotary valve just keeps repeating itself. But when the driver turns the steering wheel, the rotary valve opens up and steering fluid from the steering pump gets redirected. This time, it doesn't go back to the steering pump but it exits the rotary valve through the fluid lines and into one of the hydraulic chamber of the steering rack.

e. Hydraulic Chamber

When there is more steering fluid on one side of the hydraulic chamber, it creates a pressure differential across the chamber. The steering fluid then pushes the hydraulic piston towards the weaker side of the hydraulic chamber and the steering rack moves accordingly.

CHAPTER- 7

ELECTRIC SYSTEM OF TRACTOR

Introduction

Electrical and electronic systems have evolved over the years to become an essential element of modern off-road vehicles. A modern off-road vehicle typically incorporates an electrical system having its own power generation, storage, and distribution. Vehicle controls and diagnostics may have dozens of electronic computer-based controllers integrated into its system. Electrical system of all the tractors is almost same except one or two alterations. In some of the makes of the tractors, alternator has been introduced instead of dynamo for the recharging of a battery.

- **Functions of electrical system for a conventional off-road vehicle are:**
  - Engine starting
  - Lighting (work and safety)
  - Sensing, display, and control
  - Air conditioning/Ventilation
  - Accessory may include windscreen wiping, entertainment systems, radio, etc

2. Components of an electrical system

An electrical system of a tractor consists of the following parts/system, which are explained below

i. Battery
ii. Charging System
iii. Regulating systems
iv. Starting system
v. Relays and fuses

i. Battery:

Since the source of electricity in a tractor is the battery, let's see how it works: A battery is an electrochemical device which converts chemical energy into electrical energy. Tractors use "lead-acid" batteries. A lead-acid battery uses a series of lead dioxide plates for its positive (+) terminal and porous, soft lead for its negative plates. All the plates are arranged alternately and submerged in a solution of sulfuric acid and water. The cross section of a battery is shown in Fig. 1. The positive plate's lead oxide is a compound of lead and oxygen. Sulfuric acid is a compound of hydrogen and the sulfate radical (SO_4), so the acid's chemical designation is H_2SO_4.

Chemically, when a battery is connected to an external load (a device which uses electricity) it begins to discharge. As that happens, the lead in the positive plate combines with the sulfate of the acid, forming lead sulfate (PBSO4) in the positive plate. Oxygen in the positive plate combines with hydrogen from the acid to form water (H2O), which reduces the concentration of the acid in the electrolyte. Also, the pure lead in the negative plate combines with the sulfate, forming lead sulfate and making the positive and negative plates more alike in chemical composition. Electrons are released during this reaction, creating electrical current at a specific voltage (2 volts per cell, with 6 cells in a 12-volt battery, described below). One model HMT 7511 was installed with two batteries each of 12 V connected in parallel to meet more cranking power required to start the high hp engine.

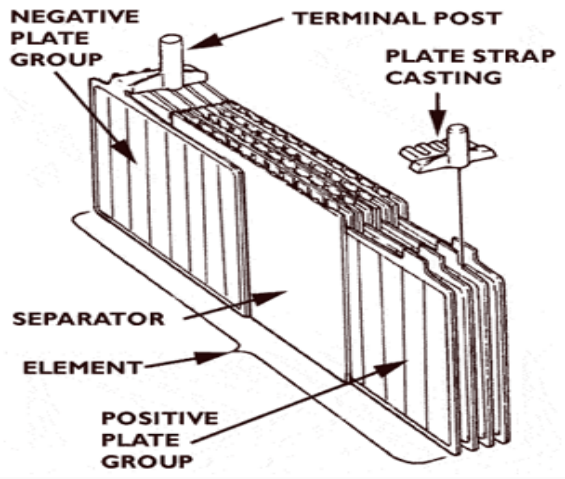


Fig. 1: Cross section of a battery

Chemical reactions:

The chemicals used in a Battery are as follows

1. Sponge Lead (Solid) in Cathode (-ve) plates
2. Lead Oxide (Paste) in Anode (+ve) plates
3. Sulphuric Acid (Liquid)

The chemical reactions take place between the three chemicals in the battery. In the presence of sulphuric acid, the electrons from one group of plates collect on the other group of plates.

The following chemical reactions take place while charging and discharging (Fig.2)

While charging

At Anode (+ve Plate): $PBSO_4 + 2H_20 => PBO_2 + 2H_2SO_4$

At Cathode (-ve Plate): $PBSO_4 + H_2 => PB + H_2SO_4$

During Discharge: The acid H_2SO_4 attacks lead to form PBSO4 (Lead sulphate)

At Anode: $PBO_2 + H_2SO_4 => PBSO_4 + 2H_20$

At Cathode combines with it to form $PBSO_4 : PB + SO_4 => PBSO_4$

So both at anode (+ ve) and at Cathode (-ve) is formed. During this process water is also formed which dilutes sulphuric acid and thereby decreases its specific gravity. This the battery converts electrical energy into chemical energy during charging and chemical energy into electrical energy during discharging.

The capacity of a fully charged battery falls down to a much lower value in fully discharged state. To know the capacity of battery two methods are adopted.

1. Ampere Hour efficiency

2. Watt Hour efficiency

Efficient (AE) = Ah at full discharge/Ah at full charge

Efficiency(Wh) = Wh output at full discharge/Wh input at full charge

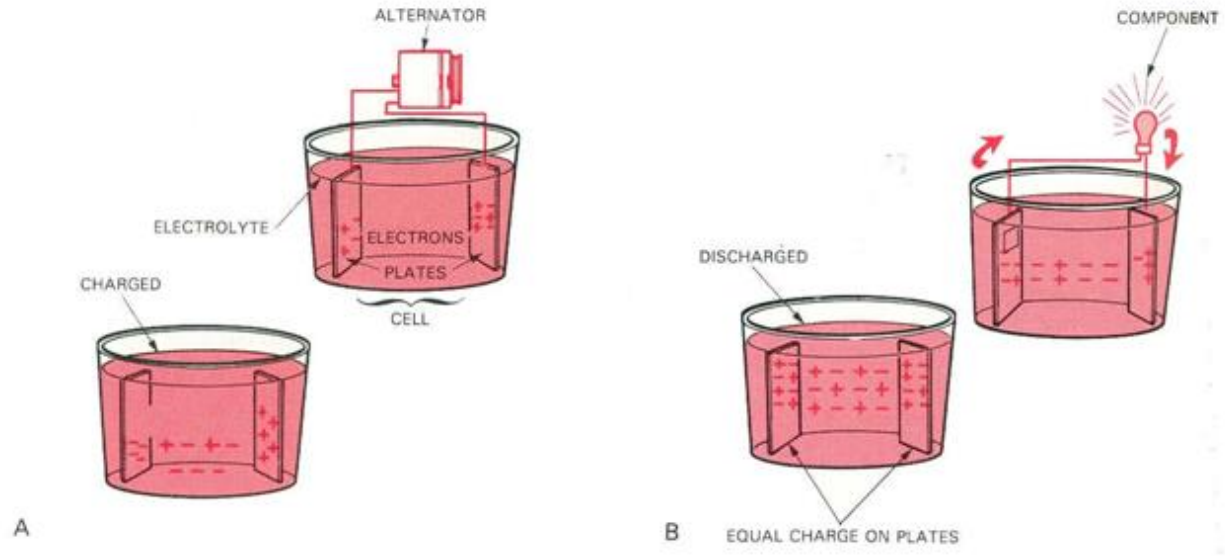


Fig.: 2. Charging and discharging of a battery

Battery Testing:

A battery can be tested to ascertain its condition by the following tests.

- Specific gravity test
- Open Volt test
- High discharge test
- Cadmium tip test

Specific gravity test: While the chemical reaction taking place in the battery during discharge, the electrolyte becomes dilute to form water. The proportion of water goes on increasing as the discharging continues. The relative amounts of water and acid is determined by the specific gravity test. This is done by Hydrometer.

The Meter of Hydrometer ranges as follows:

1.260 to 1.280	:	Fully charged
1.230 to 1.250	:	¾ charge
1.200 to 1.220	:	½ charge
1.170 to 1.190	:	Very little charge
1.110 to 1.130	:	completely discharged

Open Volt test: The Open circuit voltage of a fully charged battery cell is about 2.1 volts. This can be measured with the help of a voltmeter. It can be observed that a charge of 0.01 Volt of open circuit voltage is equivalent to a charge of 0.010 in the specific gravity of the electrolyte.

High discharge test: High Voltage of current is required for cranking the starting motor. To satisfy this condition, high discharge test is done with the help of cell voltage tester.

Cadmium Test: The test is done to ascertain whether the battery plates are defective or not. It is done with help of cadmium rod enclosed in a perforated ebonite tube. The rod is immersed in the electrolyte and connected to the negative terminal of a Voltmeter. Its positive terminal is connected alternately to the positive and negative terminals of a battery

cell. When connected with positive terminals, the voltage reading should not be less than 2.5 Volts. If it is less it indicates defective positive plates. When connected with negative plates, if it is more than 2.5 Volts, it indicates defective negative plates.

ii. Charging System (Generators or Alternators):

How the battery gets charged. In older vehicles this was done with a generator. After that time all switched to alternators.

Generator:

The basic principle at work here is that electricity produces magnetism. Conversely, magnetism produces electricity. If a current-carrying coil of wire is placed around a bar of steel, the bar will become magnetized. The more turns of wire and the stronger the current, the more powerful the magnet. By placing a soft iron core within the coil, the magnetic force lines are concentrated and strengthened. As there is less electrical resistance in the iron than in the surrounding air, the force lines will follow the core.

The various parts of a generator are shown in Fig. 3. The two pole shoes of a generator are constructed in this way. Rather than use magnets - which are heavy and expensive - many turns of wire are wound around the pole shoes. When a current passes through these windings the pole shoes become electromagnets, called FIELD COILS. These two field coils are connected in series (current passes through one and then through the other) and wound so that one becomes the North Pole and the other the south pole of the magnetic field.

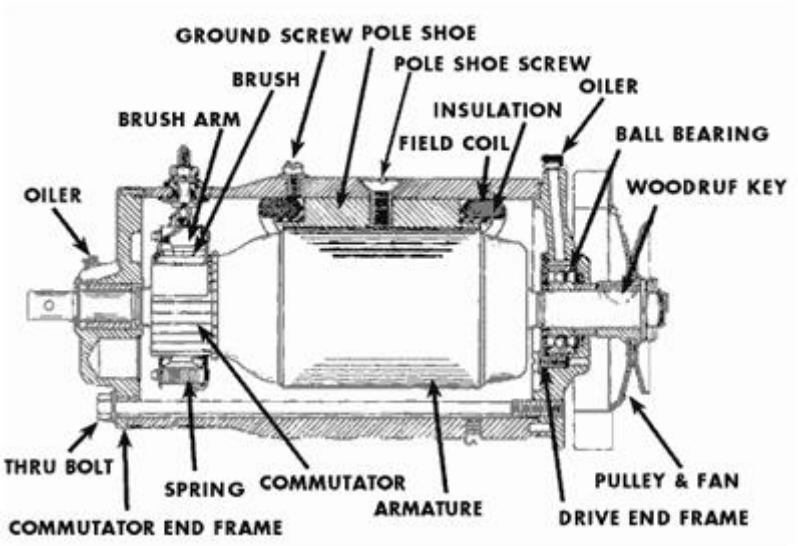


Fig. 3: Different parts of a generator

Inside the generator is a spinning central shaft which is supported in bearings at each end. Loops of wire (armature windings) are wound on a special laminated holder called the ARMATURE. The armature is turned by placing a pulley on one end of the shaft and driving it with a V-belt from the engine's crankshaft, as seen in the figure. Attached to the armature are electrical contact segments, called the COMMUTATOR. These segments are electrically insulated from the armature - and each other - but each is soldered to one of the armature windings. It is the commutator which distributes electricity to the armature in an on-off manner, creating a magnetic field around the armature. Riding over the spinning commutator segments are carbon "brushes". These brushes are held in spring-loaded brackets and that

pressure holds them against the commutator. It is the brushes which wear out over time and require replacement.

Generator Working:

When the generator armature first begins to spin, there is a weak residual magnetic field in the iron pole shoes. As the armature spins, it begins to build voltage. Some of this voltage is impressed on the field windings through the generator regulator called voltage regulator. This impressed voltage builds up a stronger winding current, increasing the strength of the magnetic field. The increased field produces more voltage in the armature. This, in turn, builds more current in the field windings, with a resultant higher armature voltage. This voltage could, of course, continue to increase indefinitely, but it is limited (by regulation) to a pre-set peak. At this point all this sounds like perpetual motion, doesn't it? Remember, though, that the energy driving all this is the engine's crankshaft!

Alternators

Generators produce Direct Current. Alternator produces an A.C. that in turn must be rectified or converted into D.C. and then stored in a battery. Alternators are more compact than dynamo (generators) systems and can supply more current at low speeds because at idle engine speeds they run at double the engine speed. Hence life of a battery is increased with the alternators.

Alternators have the advantage of producing far more current at low speeds than generators, thus allowing more and more accessories in the vehicle. In an alternator, the "field" windings are placed around the spinning central shaft rather than on "shoes" as in the generator (Fig. 4). Two iron pole pieces - cast with "fingers" - are slid on the shaft, covering the field winding so that the fingers are interspaced. The fingers on one pole piece form the North poles and the fingers on the other form the South poles. This assembly is called the ROTOR. Surrounding the rotor are a series of windings around laminated iron rings, attached to the alternator's case. This assembly is called the STATOR. The engine's crankshaft spins the rotor.

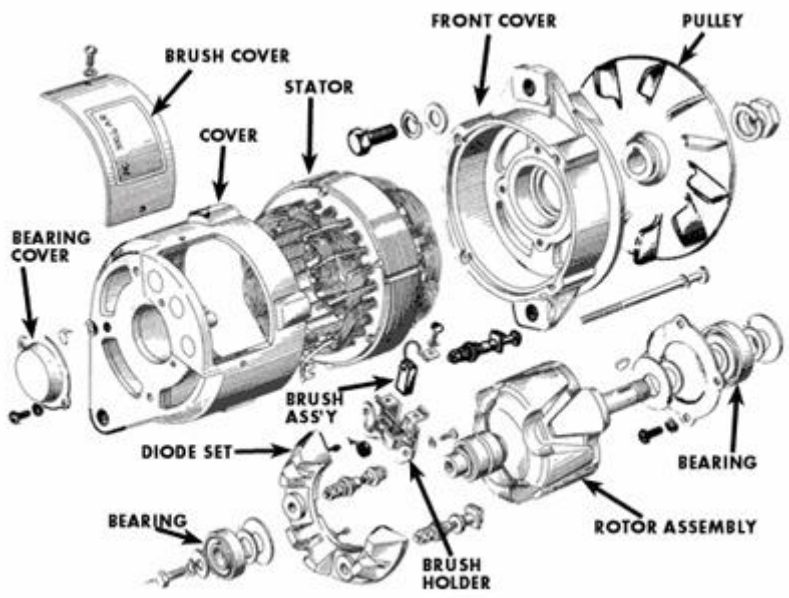


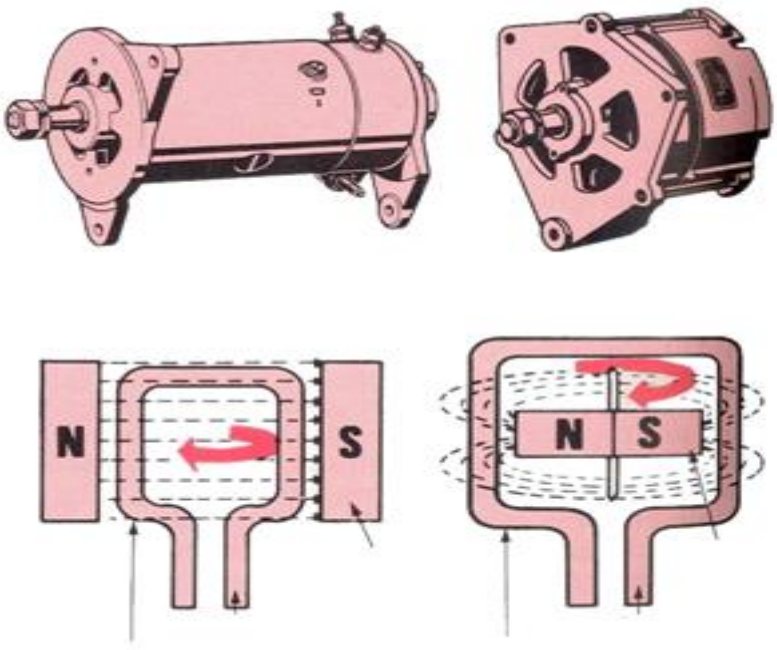
Fig. 4: Cut view of a typical alternators

Direct current from the battery is fed through into the rotor's field coil by using brushes rubbing against slip-rings. One end of the field coil is fastened to the insulated brush, while the other end is attached to the grounded brush. As the pole fields pass through the stator, current is electromagnetically produced (as in the generator) but since the rotor is composed of alternating North and South poles the current produced flows in opposite direction every 180-degrees of rotation. In other words, the current is "alternating". Difference in working of a generator and an alternator is shown in Fig. 5.

Why this is more efficient, as the stator windings are made up of three separate windings. This produces what is known as three-phase AC. When only one winding is used, single-phase current results (like in a generator). In effect, the alternator produces three times the current of a generator for the same effort on the engine's part. Also, alternators are considerably lighter and smaller than generators.

There's a small problem with alternators, though. AC electricity doesn't work in a tractor. The tractor's electrical system - and battery - need DC. Therefore, the alternator's output is "rectified" into DC. This is done by passing the AC into silicon diodes. Diodes have a peculiar ability to allow current to flow readily in one direction only, stopping the flow if the direction reverses. Multiple diodes are arranged in alternators so that current will flow from the alternator to the battery (in one direction only, creating DC) but not from the battery to the alternator.

In actual operation, the voltage regulator senses the battery voltage and overall demand on the tractor's electrical system. When charging is needed, the regulator applies battery voltage to the stator's brushes and this creates the electrical field for charging. As the system's demand for charging decreases the voltage to the brushes cuts off. All of this occurs many times per minute, with the system turning on and off repeatedly to keep everything at optimum operating efficiency.



Generator (Stationary magnetic field) Alternator (Rotating magnetic field)

Fig. 5: Difference in working of generator and alternator

iii. Regulating system

As, there is no system of internally controlling the output of an alternator or in other words, the faster it spins the more voltage goes into the electrical system. If this weren't controlled the generator would damage the battery and burn out the lights. Also, if the generator weren't cut out from the tractor's circuitry when not running, the battery would discharge through its case.

That's where the REGULATOR (commonly called the Voltage Regulator, but that's only one component of the system) comes in. Regulators have seen many design improvements over the decades, but the most commonly used electro-mechanical regulator is the three-control units in one box type. These are explained below,

(a) Cutout Relay

Sometimes called the circuit breaker, this device is a magnetic "make-and-break" switch. It connects the generator to the battery (and therefore the rest of the tractor) circuit when the generator's voltage builds up to the desired value. It disconnects the generator when it slows down or stops.

The relay has an iron core that is magnetized to pull down a hinged armature. When the armature is pulled down a set of contact points closes and the circuit is completed. When the magnetic field is broken (like when the generator slows down or stops) a spring pulls the armature up, breaking the contact points.

An obvious failure mode is the contact points. As they open and close, a slight spark is generated, eventually eroding the material on the points until they either "weld" themselves together or become so high in resistance that they won't conduct current when closed. In the first case the battery would discharge through the generator overnight and in the second there would be no charging to the system.

(b) Voltage Regulator

Another iron core-operated set of contact points is utilized to regulate maximum and minimum voltage at all times. This circuit also has a shunt circuit (a shunt re-directs electrical flow) going to ground through a resistor and placed just ahead (electrically) of the points (Fig. 6). When the points are closed the field circuit takes the "easy" route to ground but when the points are open the field circuit must pass through the resistor to get to ground.

The field coil on the generator is connected to one of the voltage regulator contact points. The other point leads directly to ground. When the generator is operating (battery low or a number of devices running) its voltage may stay below that for which the control is set. Since the flow of current will be too weak to pull the armature down the generator field will go to ground through the points. However, if the system is fully charged the generator voltage will increase until it reaches the maximum limit and current flow through the shunt coil will be high enough to pull the armature down and separate the points.

This cycle is repeated over and over in real time. The points open and close about 50 to 200 times per second, maintaining a constant voltage in the system.

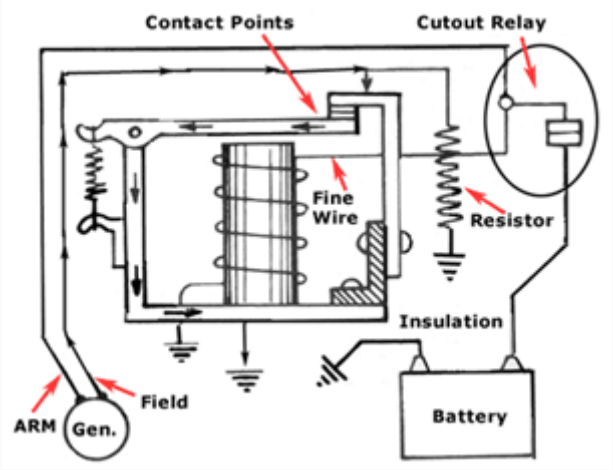


Fig. 6: View of a typical voltage regulator

(c) Current Regulator

Even though the generator's voltage is controlled it is possible for its current to run too high. This would overheat the generator, so a current regulator is incorporated to prevent premature failure (Fig. 7).

Similar in appearance to the voltage regulator's iron core, the current regulator's core is wound with a few turns of heavy wire and connected in series with the generator's armature. In operation, current flow increases to the predetermined setting of the unit. At this time, current flow through the heavy wire windings will cause the core to draw the armature down, opening the current regulator points. In order to complete the circuit the field circuit must pass through a resistor. This lowers current output, points close, output increases, points open, output down, points close, and so on. The points, therefore, vibrate open and closed much as the voltage regulator's points do, many times every second.

Because they are mechanical, voltage regulators are easy to troubleshoot. If you study the function of each of the three parts and how they interrelate, it becomes obvious which part is malfunctioning, depending upon symptoms. The point gaps and spring pressures determine the voltage/current limits and they are exceedingly hard to adjust. Sometimes it can be done on the tractor using a voltmeter, but generally it is best to replace the enTYRE regulator assembly when a certain part of it fails. Factory assembly of regulators required relatively sophisticated measurement instruments. Adjusting them by "feel" is a matter of luck, and frequently can result in damage.

It wasn't long thereafter that the automobile companies converted to transistor voltage regulators. Utilizing Zener diodes, transistors, resistors, a capacitor and a thermistor, these regulators maintain proper voltage and current flow throughout the system. Their circuitry operates as fast as 2,000 times per second and they are tremendously reliable. On the other hand, these regulators aren't easy to repair. They are designed to be thrown away and replaced. Alternators provide three times the current and weigh much less than their old counterparts.

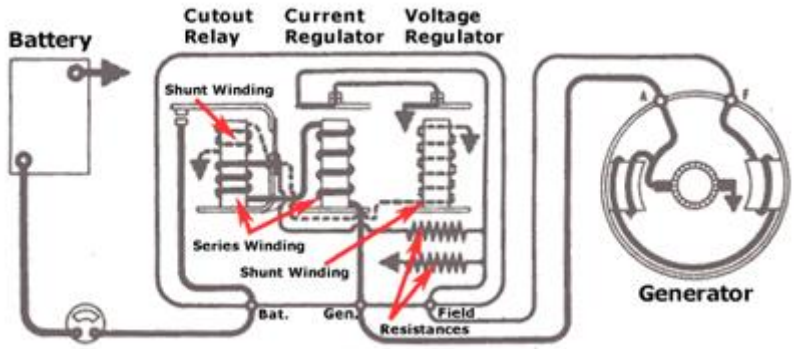


Fig. 7: Voltage and current regulators

d. Starting System:

Electrical system only needs 80 to 100 amps of current for general running, even when all accessories are operating. Then, why battery does have a rating of 450 to 740 amps or even more. The main reason for the battery's storage capacity is to operate the starter, and a quick look at the numbers will demonstrate why this is so important:

Let's take a 500-amp-rated battery for example. At 12 volts, this 500 amp battery is capable of putting out 6000 watts. We need all the wattage we can get to develop enough horsepower to turn the engine over for ignition and one horsepower (or the power necessary to lift 550 pounds (249.47 kg) one foot in one second) equals 746 watts. Our battery, therefore, puts out just over eight horsepower. That's just enough for a couple hundred revolutions of the engine before the charge is exhausted. Starters are incredibly strong motors that work in a hostile environment. They are the most important part of the starting system (Fig. 8) or circuit, consisting of the following:

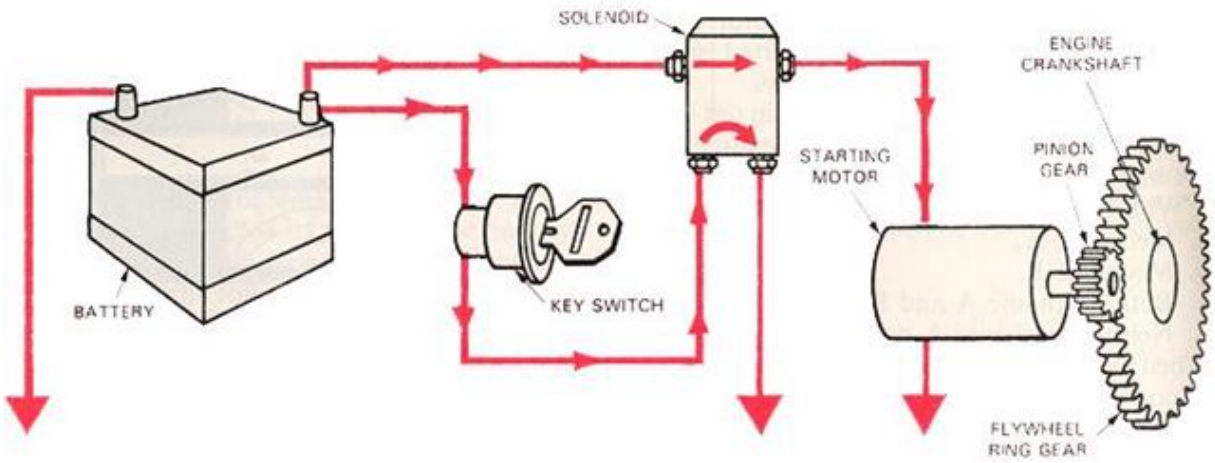


Fig. 8: Starting system of a tractor

Flywheel ring gear - This is a toothed ring that is fitted to the outside of the engine's flywheel. Matching teeth on the starter motor mesh with this gear in order to spin the crankshaft.

Starter solenoid (Relay) - The starter solenoid has very large contacts to carry the battery's full current. Its wire coil is actuated by a smaller current from the ignition switch, at which time the iron core slams down to make contact and turn on the starter motor. Most non-Ford starter motors employ a solenoid built into the motor itself. This type of solenoid

not only provides the motor's electrical power but also mechanically engages the starter's drive gear onto the flywheel. It is commonly known as the BENDIX type of solenoid. Such solenoids operate in three stages, the disengaged, partially engaged and engaged. In the disengaged position the drive gear is released and no current is flowing. In the partially engaged stage, current from the starter switch flows through both the pull-in and the hold-in coils. Both coils draw the plunger inward, causing it to pull the shift lever and engage the pinion gear. When the plunger is pulled into the coil all the way, the pinion fully engages the ring gear. When the ring gear is fully engaged, engine cranking begins. When the engine starts the hold-in coil will cut out and the plunger will move out, retracting the pinion and opening the starter switch.

Starter motor - This is a powerful electric motor that engages the car's flywheel in order to spin the crankshaft. As in all electric motors, the starter is composed of windings of wire that form loops, ending at the commutator segments (remember these from the generator?). The armature coils are mounted on the motor's central shaft (supported with bearings) and the field coils are formed into four or more "shoes", placed inside the steel frame of the starter. Brushes are used to create electrical contact to the commutator segments and when current is fed into two of the four brushes, it flows through all the loops of the armature and shoe windings and out the other two brushes. This creates a magnetic field around each loop. As the armature turns, the loop will move to a position where the current flow reverses. This constant reversal of current flow allows the armature and field coils to repel each other and spin the motor. The greater the current flowing in the coils, the greater the magnetic forces, and the greater the power of the motor.

The copper loops and field windings are heavy enough to carry a large amount of current with minimum resistance. Since they draw heavy amounts of current, they must not be operated on a continuous basis for longer than 30 seconds. After cranking for 30 seconds it is wise to wait a couple of minutes to let the starter motor dissipate some of its heat. Starters heat quickly, so prolonged use can cause serious damage. A typical symptom of overheating starter motors is extremely slow, labored engine-cranking.

Various wiring designs are used in starter motors and one of the most popular is the four pole, three winding setup. Two of the windings are in series with themselves and the armature. One winding does not pass through the armature, but goes directly to the ground. This Shunt Winding aids with additional starting torque. However, as the starter speed increases, the shunt still draws a heavy current and tends to keep starter speed within acceptable limits.

e. Relays and fuses:

All tractors are wired so that the battery's main cable connects to the starter motor windings (the thick cable is needed for large current flow). This wire must be switched on and off, and it would be costly and inefficient to route it through the ignition switch. Hence a relay is necessary.

Relays are devices that utilize a central iron core fitted closely to the inside of a coil of wire. When the wire is energized the iron core will be drawn down the length of the coil, the direction dependent upon the direction of current flow. If the relay's iron core is fitted with large, high current-carrying contacts it can be used as a high-current switch. Relays are used for horns, electric fans, air conditioning clutches, etc. and the most important one is the starter solenoid.

Almost everything in a tractor is wired through a fuse. Fuses are designed to fail when too much current is drawn through the device. This prevents heating of the wires and subsequent melting of the insulation, followed usually by fire!

Fuses are simple in design. Inside a fuse is a soft wire with a specific cross-sectional thickness. This dimension dictates how many amps can be carried before the wire melts. Too many amps and the fuse fails, saving the rest of the circuit from damage.

Typical horn circuit having various components are put together to form a working system:

Battery voltage travels through a high current wire (red) through the relay to the horn and also through a smaller wire (blue) through the ignition switch to the relay's low-current coil. Important thing is that horn circuit is always "hot" or "live" when the ignition switch is turned on and all that's needed is a path to ground (Fig. 9).

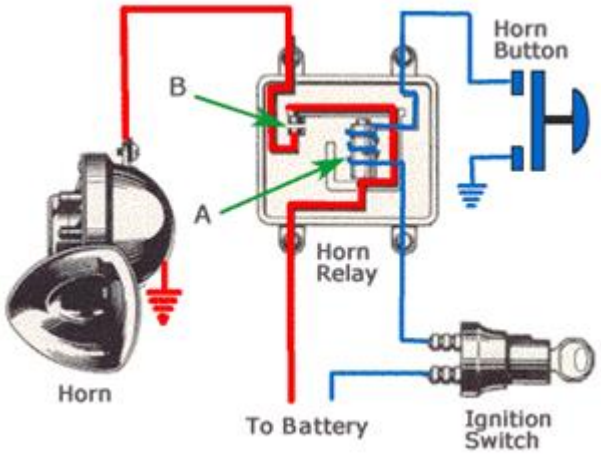


Fig. 9: Horn relay system

That path is completed when pushed the horn button. When the button is pushed the ground connection is made, energizing the relay's coil "A". The coil's iron core (in this particular design) pulls down arm, connecting high-current contacts "B". High current then flows from the battery to the horn (the horn is connected to ground because it's mounted to the chassis of the vehicle).

CARE AND MAINTENANCE OF TRACTOR BATTERY

Tractor batteries are essential for starting and operating the tractor. However, they can also be a source of problems if they are not properly cared for and maintained.

Here are some tips on how to care for and maintain your tractor battery:

- Keep the battery clean and free of corrosion. Corrosion can build up on the battery terminals and cables, which can interfere with the flow of electricity. Use a wire brush to clean the terminals and cables regularly.
- Check the battery electrolyte level regularly. The electrolyte level should be between the upper and lower level marks on the battery case. If the electrolyte level is low, add distilled water to bring it up to the proper level.
- Charge the battery regularly. If the tractor is not used frequently, it is important to charge the battery regularly to prevent it from discharging. Use a battery charger that is designed for tractor batteries.

- Store the battery in a cool, dry place. If the tractor is going to be stored for an extended period of time, disconnect the battery and store it in a cool, dry place.

CHAPTER- 8

Periodical Maintenance of Tractor

Periodical Maintenance of Tractor

These few very small activities can ensure that tractor runs for the designed service life. Service schedules generally maintain these conditions. Since, it is not necessary and possible also to carry out all above activities every hour. Activities required to be carried out at regular intervals to maintain these conditions are mentioned in service scheduled. Generally these are classified as 10, 50, 125, 250, 500, 1000 hour service schedule. The activities carried out in these schedules may vary marginally from one manufacturer to another for example ten hour service schedule list the activities to be carried out after a day‟s work at Farm. The list of activities to be carried out in 10 hour service schedule has been listed below.

List of activities to be carried out in 10 hours service schedule (daily maintenance):

1. Clean the tractor, if the tractor worked under dusty conditions & wash it with a swift jet of water to remove the dirt and wipe off with a dry cloth.
2. Inspect the tractor critically to ensure that no leakage is taking place at any point, take correct steps with the help of authorised service centre if the need be.
3. Check all the nuts and bolts for tightening properly on different parts of the tractor and replace the broken ones, if any.
4. Top up the fuel level in the fuel tank at the end of each days operation. This will keep your tractor ready for "next day and avoid condensation of water at the bottom of tank or in the fuel line.
5. Check and top up, if necessary crank case with mobile oil. Dip stick with low and full level mark is provided for the purpose. The oil level should be in the middle of these two marks.

Weekly Maintenance (After 50-60 hours of work):

1. Repeat the daily maintenance measure.
2. Check the air pressure in the tyres. If the pressure is low, get the necessary air.
3. Check the elasticity of the fan-belt under the pressure of the thumb. It should stretch to a degree of 12 & 18 millimeters.
4. Clean the air pressure and fill it with an oil of the right grade.
5. The water stored in the oil filter should be drained out by the drain plug.
6. Check the water-level of the battery. If water is found below the limit, fill it with distilled water.
7. Check the level of the oil in the gear box.
8. Apply grease to the clutch shaft and bearings, brake control, bearing of the fan, hub of the front wheel, tie rod, etc.

Fortnight Maintenance (After 120 to 125 hours of work):

1. Repeat the weekly schedule of maintenance.
2. Apply oil to the Dynamo and the starter. 3

. Clean the carbon in the smoke-tube.

4. Change the engine oil. To do so, keep the tractor in starting position for a while and then switch it off so as to heat up the enTYRE oil, then drain out the oil through the drain plug and fill fresh and clean oil of the right grade.

5. In case the oil filter is made of paper, element, cloth, felt, etc. change them. Clean the metallic oil filter.
6. Check the free play of clutch and brake, it should be 15mm long. Adjust it according to the need.

Monthly Maintenance (After 250 hours of work):

1. Repeat every step of fortnightly maintenance.
2. If it is advised to clean the primary diesel filter, (in the manual supplied with the tractor) clean it or change it.
3. Wash the filters of the tap of the oil-tank.
4. Check the water in the battery. If its relative density is below the mark, change the battery.

Two Months Maintenance (After 500 hours of work):

1. Follow the monthly schedule of maintenance.
2. Change the other element of diesel filter.
3. Get the injector and diesel pump checked either by an authorized dealer or an experienced mechanic.
4. Contact your authorized dealer or an experienced mechanic for the inspection of valve.
5. Get the dynamo and the self-starter inspected.
6. Open the oil tank and clean it.

Four Months Maintenance (After 1000-1200 hours of work):

1. Follow the bi-monthly maintenance schedule.
2. Drain out the oil of the gear box and fill it with a clean oil of the right grade.
3. Drain out the oil of the back-axle and fill clean oil.
4. Change the oil of the belt-pulley.
5. Clean the filter of the hydraulic pump.
6. Change the steering oil.
7. Change the grease of the front wheel.

CHAPTER-9

SELECTION OF TRACTOR

Selection of tractors depend up on following factors:

1. **Land holding:** Under a single cropping pattern, it is normally recommended to consider 1 hp for every 2 hectare of land. In other words , one tractor 20-25 hp is suitable for 40 hectare farm
2. **Cropping pattern:** Generally 1.5 hectare/hp has been recommended where adequate irrigation facility is available and more than one crop is taken. So a 30-35 hp tractor is suitable for 40 hectare of land.
3. **Soil condition:** A tractor with less wheel base , higher ground clearance and low overall weight may work successfully in lighter soils buy will not be able to give sufficient depth in black cotton soils.
4. **Climatic condition:** For very hot zone and desert area, air cooled engines are preferred over water cooled engines. Similarly for higher altitude air cooled engines are preferred because water cooled engines are liable to be frozen at high altitudes.
5. **Repair facilities:** It should be ensured that the tractor to be purchased has a dealer at nearby place with all the technical skills for repair and maintenance of the machine.
6. **Running cost:** Tractors with less specific fuel consumption should be preferred over others so that the running cost may be less.
7. **Initial cost and resale value:** While keeping the resale value in mind, the initial cost should not be very high, otherwise higher amount of interest have to be paid.

Tractor operation safety precautions:

a) General Points:

1. Run and maintain the tractor according to the operator's Manual of Tractor provided by the tractor manufacturer.
2. Check the working of all controls just after riding the tractor.
3. Release the parking brakes before starting.
4. Be alert and alert to drive it safely.
5. Whenever the tractor is stopped, even for a short while gear-shift lever should be brought to neutral position.
6. Always park the tractor with gear shift lever in the neutral position and with parking brake applied.
7. Operate the tractor smoothly; avoid jerky starts, turns and stops.
8. Drive slowly in difficult conditions.
9. Look at the rear while reversing the tractor.
10. Attend immediately to oil and fuel leakages.
11. Listen to the noise or sound in the engine, power transmission, etc., if any abnormal noise is noticed stop the tractor and investigate the causes.
12. Always keep a watch ahead of the tractor.
13. When stopped put the tractor out of gear, set brakes firmly.
14. Refuel the tractor only when the engine is cool, don't spill fuel and never smoke while refuelling.
15. Hitch implements only to drawbar or specified hitch points of the tractor.

16. Air intake assembly must be removed before raising the bonnet.
17. Beware of oily steps & slippery platforms.
18. Never drive after taking alcohol drink or drugs.
19. Never run the tractor engine in a closed shed or garage.
20. Don't permit unauthorised' persons to ride the tractor unnecessarily.
21. Never operate the hand accelerator of tractor from the ground.
22. Do not allow the tractor wheels to run over sharp objects.
23. Do not keep foot (ride) on the clutch and brake pedals while the tractor is running.
24. Do not sit or stand on the implement when the tractor is in motion.
25. Do not attempt the dual selector lever when the tractor is in motion.
26. Avoid spilling fuel over the engine.
27. Avoid overloading of the tractor during operations.
28. Do not get off or on the tractor when it is in motion.
29. Do not remove the radiator cap while the engine is hot.
30. Never leave the key in the starting switch.

b) Points to be considered for safety on the Farm

1. Set the wheels as wide as required for the job. Use wider wheel track on slopes for stability.
2. Add weights on rear or front, as the case may be, for proper traction.
3. Keep P.T.O. and belt pulley shields in proper place.
4. Do not hook load at a point above the drawbar.
5. Reverse the tractor in low gear.
6. Driver tractor in low gears while overcoming obstacles like small bunds and ditches.
7. Draft control should not be used for raising or lowering the implements at the end of trip/ row.
8. Do not ride the drawbar of tractor during operation.

c) Points for Road Safety

1. Obey the traffic rules while driving on road.
2. Drive slowly while making turns.
3. Use lower gear during up and down-hill driving.
4. Be careful during road crossing.
5. Stop the tractor on the left side of the road.
6. Keep brake pedals interlocked when driving on the road.
7. Give way to automobile vehicles.
8. While driving at night with trolley, do make extensive provision for lights at the rear as well as on the sides.
9. Never coast down- hill in neutral gear.
10. Never depress clutch pedal while driving down-hill.
11. Do not tend to turn sharply using independent brakes when travelling at high speeds.
12. Do not overload trolley.
13. Do not drive without rear-view mirrors.

Cost analysis of use of tractors:

Under cost analysis the cost incurred per hour of operation of a tool/ implement/ machine is calculated. This will give an idea of the payback period of the investment. This cost serves as

the basis to fix up hire charges of the implement for custom hiring

Total cost of operation of an implement/ tool involves two costs namely :

1. Fixed cost

2. Variable cost or operating cost

Fixed cost – This cost relates to machine ownership. This cost can occur regardless of whether the machine is used or not. Fixed cost is inversely proportional to the annual use. It includes depreciation, interest on investment, taxes, insurance and housing costs
Variable cost or operating cost – Those costs which are directly related to the amount of use are called variable costs. These costs are incurred only when the machine is used. Variable costs include repair and maintenance, fuel and lubricants, servicing and labour charges.

A. Calculation of fixed cost

1. **Depreciation -** It is the reduction in value of the machine with the passage of time. In the usual situation with field machines being operated only a few days in a year year, obsolescence is the most important factor affecting the depreciation (**Obsolescence** is the state of being which occurs when a person, object, or service is no longer wanted even though it may still be in good working order). A machine may become obsolete because of the development of improved models, changes in farm practices etc.
2. The following expression based on the straight line method is used to calculate the depreciation

$$D = \frac{C-S}{L \times H}$$

Where,
D = Depreciation cost, Rs/hr
C = Initial cost of the machine, Rs
S = Salvage value of the machine, usually taken as 10 per cent of the initial investment of the machine Rs,
L = Expected life period of the machine, years
H = Number of working hours per year

Note: Salvage value is the estimated value of an asset at the end of its useful life

3. **Taxes and Insurance**

This cost usually is much smaller than depreciation and interest, but they need to be considered. A cost estimate equal to 1.0 percent of the purchase price often is used.

4. **Housing**

Providing shelter, tools, and maintenance equipment for machinery will result in fewer repairs in the field and less deterioration of mechanical parts and appearance from weathering. That should produce greater reliability in the field and a higher trade-in value. An estimated charge of 1.0 percent of the purchase price is suggested for housing costs.

5. **Total Ownership Cost (Fixed Cost)**

The estimated costs of depreciation, interest, taxes, insurance, and housing are added together to find the total ownership cost. If the tractor/Machinery is used 500 hours per year, the total ownership cost per hour is: Ownership cost/use hours per year

B. Calculation of Operating cost

Operating costs (also called variable costs) include repairs and maintenance, fuel, lubrication, and operator labour.

1. **Repairs and Maintenance**

Repair costs occur because of routine maintenance, wear and tear, and accidents. Repair costs for a particular type of machine vary widely from one geographic region to another because of soil type, rocks, terrain, climate, and other conditions. Within a local area, repair costs vary from farm to farm because of different management policies and operator skill. The best data for estimating repair costs are the operator's own records of past repair expenses. Good records indicate whether a machine has had above or below average repair costs and when major overhauls may be needed. They also will provide information about the operator's maintenance program and mechanical ability. Without such data, repair costs must be estimated 5-8 percent of purchase price of tractor/power tiller per year.

2. **Fuel**

Fuel costs can be estimated by using average fuel consumption for field operations in liters per hour. Those figures can be multiplied by the fuel cost per litre to calculate the average fuel cost per hour/hectare.

3. **Lubrication**

The total lubrication costs on most farms average about 15 percent of fuel costs. Therefore, once the fuel cost per hour has been estimated, it can be multiplied by 0.15 to estimate total lubrication costs.

4. **Labour**

Because different size machines require different quantities of labour to accomplish such tasks as planting or harvesting, it is important to consider labour costs in machinery analysis. Labour cost also is an important consideration in comparing ownership to custom hiring. Actual hours of labour usually exceed field machine time by 10 to 20 percent, because of travel time and the time required to lubricate and service machines. Consequently, labour costs can be estimated by multiplying the labour wage rate times 1.1 or 1.2. Using a labour value of Rs 50 per hour for our tractor. Different wage rates can be used for operations requiring different levels of operator skill.

Total Operating Cost

Repair, fuel, lubrication, and labor costs are added to calculate total operating cost.

Total Cost

After all costs have been estimated, the total ownership cost per hour can be added to the operating cost per hour to calculate total cost per hour to own and operate the machine.

Implement Costs

Costs for implements or attachments that depend on tractor power are estimated in the same way as for the example tractor, except that there are no fuels, lubrication, or labor costs involved.

Traction

Traction is the force derived from the soil to pull a load. This force is exerted against the soil by a traction device such as a wheel, track, winch sprig, or spade. The dynamic resistance of the soil to provide traction is supplied through an interaction between the traction device and the soil. This interaction is very complex and little headway has been made in solving some of the problems that result from the interaction.

Traction Mechanics

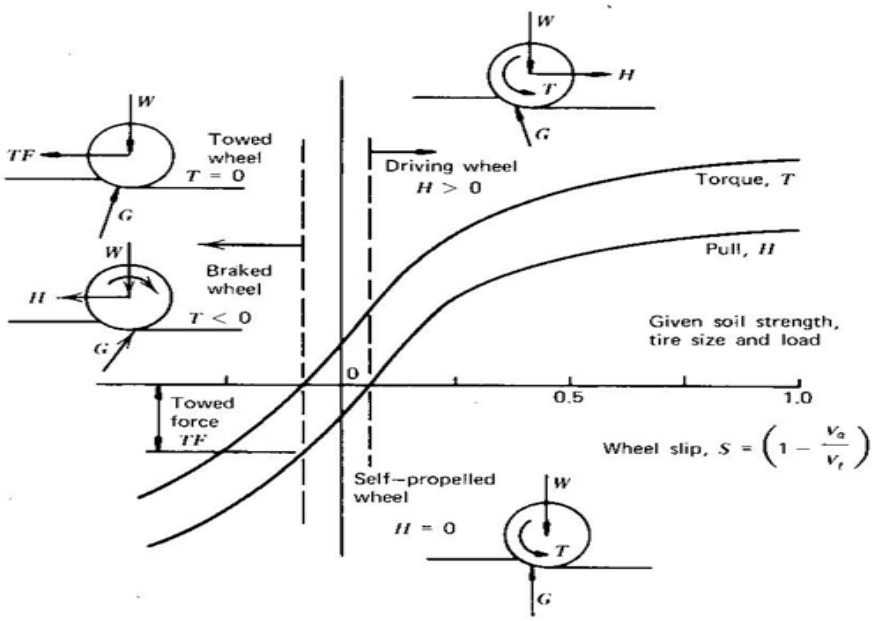


Fig. Pull- torque slip relation for wheels on soi

Fig. shows one of several alternative methods of describing the forces acting on a wheel. The figure is divided into three distinct force states: braked, driven, and driving. The transition point between the braked and driven force states is the towed wheel condition. A towed wheel is unpowered: axle torque is zero neglecting bearing friction. The transition point between the driven and driving force states is the self-propelled wheel condition. For a self-propelled wheel, pull is zero with the applied torque simply overcoming the motion resistance of the wheel.

Tractive Efficiency:

The pull, torque and slip characteristics of a driving wheel define both the magnitude and efficiency of tractive performance. The pull/weight ratio or net tractive coefficient is an accepted term for defining performance level. Similarly, the term tractive efficiency (TE) has been adopted to define efficiency. Tractive efficiency of a wheel is defined as:

$$TE = \frac{\text{output power}}{\text{input power}}$$

Rolling resistance

Rolling resistance is the force opposing horizontal motion on a deformable surface or on flexible tyres. It can be considered as a rate of energy loss to the soil and /or tyres. It has been known in practice that the rolling resistance of a tyre increases both with the vertical load on the wheel and with the sinkage of the tyre into the soil. Industry rules of thumb are available for approximate calculations for earthmoving tyres in a range of outside diameters from 150 to 300 cm.

Some traction conditions that affect performance are:

- Soil parameters (physical properties)
- Presence of crop residues and cover crops
- Direction of loading of tire (e.g., hillside use)
- Load carried by tire
- Tire pressure (deflection ratio = deflection/tire section height)

The decision as to which tire tread performs best is also dependent on the criteria being used. Some of the criteria are:

- Tractive efficiency
- Net tractive coefficient
- Tire life
- Soil compaction

Procedure of testing and standard code for testing of tractor performance

The International Organization for Standardization (ISO) is the apex body in the area of standardization at international level and has its membership on National Standards Bodies of various countries. In the context of farm machinery, it has been observed that acceptance of farm machinery by the farmers largely depends on their quality. Hence, in order to reap the benefits of standardization including manufacture of high quality products, a need was felt for preparation of India Standards for agricultural machinery. Organized efforts in this direction were made by the Bureau of Indian Standards (BIS) in late 50's by way of setting up a Technical Committee for formulation of standards for this group of industry. The committee is generally consisted of representatives of Government department, research, education and testing institutions and the manufacturing industries.

Importance of testing:

Testing of a machine means systematic determination of functional performance, structural strength, durability, power requirements and capacity by running the test under a wide range of conditions in the laboratory and field. Testing is useful for all the stakeholders like manufacturers, consumers/farmers, exporters, export inspection agencies as well. How testing is important for

Manufacturers:

- Streamlining of production processes and introduction of quality control system.

- Independent audit of quality control system by BIS

- Reaping of production economies accruing from standardization

- Better image of products in the market both internal and overseas

- Winning for wholesaler's retailers and stockiest consumer confidence and goodwill

- Preference for standard marked products by organized purchasers agencies of Central and State government, local bodies, public and private sector undertaking etc. Some organized purchases offer even higher price of standard marked good.

- Financial incentives offered by the Industrial Development Bank of India (IDBI) and nationalized banks.

- To know where his machine stands in comparison with similar types of machines in the market, and he can improve his product.

- It enables him to add more information to the technical literature relating to the machine.

Consumer

- Conformity with Indian standards by an independent technical national level organization.

- Helps in choosing a standard product

- Free replacement of standard marked products in case of their being found to be of substandard quality

- Protection from exploitation and deception

- Assurance of safety against hazards to life and properly

- The knowledge of the comparative performance of similar type of machinery will help the user to choose an appropriate machine to his requirement at the lowest cost

Organized purchasers

- Convenient basis for concluding contracts

- Elimination of the need for inspection and testing of goods purchased saving time, labour and money

- Free replacement of products with Standard Mark found to be substandard

Exporters

- Exemption from pre-shipment inspection wherever admissible.

- Convenient basis for concluding export contracts

Export Inspection Authorities

- Elimination of the need for exhaustive inspection of consignments exported from the country, saving expenditure time and labor.

Authority for testing:

Testing of tractors is being conducted since 1919, when the Nebraska Tractor Test Law took effect in USA. The idea for official tractor testing at the University of Nebraska, Lincoln (UN-L) was started when Polk County farmer purchased a lemon back in 1916. Tractors were something new on the farm then, just beginning to replace real, live, oats-

powered horsepower. Farmer bought a "Ford B" tractor to replace his mule team, from the Minneapolis, Minnesota Ford Tractor Company. New purchased tractor gave him so much trouble that he demanded a replacement from the company, but the replacement tractor was no better than earlier one. A representative of every model of tractor rated at 40 horsepower or more sold in USA, must be tested at the Nebraska Tractor Test Laboratory (NTTL) on East Campus. Today, NTTL is the only officially designated agriculture tractor testing lab in the Western Hemisphere, elevated to worldwide status as a sanctioned testing station for the Paris-based Organization for Economic Cooperation and Development (OECD). There are other active testing facilities in Germany, France, Italy, Spain, Japan and China for instance, but for U.S. farmers and tractor owners, it all comes down to the track of concrete at UN-L. Central Farm Machinery Training and Testing Institute, Budni (MP) is responsible for testing of the locally manufactured tractors in India.

OECD Tractor Codes allow participating countries to perform tractor tests according to harmonized procedures, and to obtain OECD official approvals which facilitate international trade. The codes cover the testing of:

- Tractor performance - All tested tractors must complete compulsory tests of: engine power output and fuel consumption; drawbar power output and fuel consumption; hydraulic power output; hydraulic lift capacity. In addition, the manufacturer can complete optional test procedures including: braking performance, turning area and turning circle; low temperature starting; centre of gravity location; external noise level; axle power; engine (bench) test); waterproofing test; performance in a hot atmosphere.
- Noise levels at the operator's driving position
- Operator safety - Roll-over Protective Structures (ROPS) and Falling Object Protective Structures (FOPS)

❖ **Major testing and evaluation centers in India for Agricultural Machinery**

Following organizations are involved in testing of agricultural machinery. But CFMTTI, Budni is involved in tractor testing as a main authority in India.

I. Central Farm Machinery Training and Testing Institute, Budni, Madhya Pradesh-
II. Northern Region Farm Machinery Training and Testing Institute, Hisar, Harayana
III. Southern Region Farm Machinery Training and Testing Institute, Anantpur, Andhra Pradesh
IV. Eastern Region Farm Machinery Training and Testing Institute, Biswanath Chariali, Distt. Sonitpur (Assam),
V. BIS Testing Laboratory, Sahibabad, Uttar Pradesh
VI. BIS Centers of Tractor, Power Tiller, Diesel Engine, Electric Motor, Irrigation Pumps
VII. ICAR Institutes
VIII. Agricultural Universities
IX. Central Food Technology Research Laboratory, Mysore, Karnataka

Procedure of testing

BIS has published standards on machine/components for the machines used in the country. Mostly testing of the particular machine is undertaken as per relevant clauses of the code. In case, the standard has not been published for the machine, code and procedure is developed by the testing center and same used for testing purpose. These test procedures help in formulation of test codes by BIS. The complete testing of a machine involves:

i. Checking of specifications

ii. Development of test facilities and instrumentation

iii. Conduct actual tests

iv. Analysis of the data

v. Presentation of data and report writing

vi. Product certification marks scheme

i. Checking of specifications: Generally the test codes include few important specifications of the machine/equipment those are mandatory to meet a specific requirement. Few specifications have to be specified by the manufacturer and the testing center has to verify such dimensions within the tolerance limits.

ii. Development of facilities and instrumentation: The test codes give a guide line for development of test set up required for carrying out a specific test in the machine/equipment/component. The testing center has to develop a setup which should meet the requirements specified in the test procedure of the test center. As far as possible the high quality instrumentation should be included in the test set ups.

iii. Conduct actual tests: The actual tests should be carried out on the machine as per the test procedure specified and data recorded in the given blank tables.

iv. Analysis of data: The data obtained during testing is analyzed for presentation in the required format. Use of computer should be encouraged.

v. Presentation of data and report writing: The report should include the sections for the clauses those comply with the standard and those do not conform to the standards.

vi. Product Certification Marks Scheme: The Bureau operates a certification marks scheme under the Bureau of Indian standards Act, 1986 and the Rules and regulations framed there under. The Bureau's standard Mark (ISI) on an article certifies that the article complies with the requirements specified in the relevant Indian standards and also guarantees that the manufacturer operates a quality control system in his production which is monitored in terms of regular inspections and checks in such a form as to give assurance that the article will comply with the requirements of the relevant Indian standards. The Certifications Marks schemes also provide an inbuilt mechanism for ensuring the quality of the product right from the raw material stage to the finished product. The BIS Certification Marks Scheme is operated on voluntary basis.

Bureau of Indian Standards (BIS) for Tractors:

Tractor Test:

The brief outline of various types of tests performed by Center of Farm Machinery Testing and Training Institute (CFMTTI), Budni (MP) are as under. Tractor test is carried out in accordance with Indian Standard (IS):5994-1998 as amended from time to time. A tractor is subjected to the following tests & evaluation

Laboratory Tests

- Checking of specifications
- PTO performance test
- Belt pulley test(optional)
- Drawbar performance test
- Power lift & hydraulic performance test
- Brake test
- Air cleaner oil pull over test
- Noise measurement
- Mechanical vibration measurement
- Location of centre of gravity
- Turning ability
- Visibility

Field tests: -

For Initial commercial tests (ICT) for 35 h and for batch test of 35 h. (if there is any major breakdown during the ICT) of field tests with the following implements

Plough/ Rotavator(20 hrs. for I.C.T & 20 hrs for Batch Test)

Puddling test of 10 Hrs. duration under actual field conditions followed by Water Proof Test of 5 h for ICT and batch test if applicable.

Haulage test: This is done with 2/4 wheel trailers and the gross load recommended by the manufacturer. Components & assembly inspection is done to assess the wear, breakdowns, etc.

Power Tiller Test

Performance evaluation of power tiller is conducted in accordance with Indian Standard (IS):9935-2002 as amended from time to time.

A power tiller is put into the following tests and evaluation:

Laboratory Tests

- Specification checking.
- Engine performance test.
- Rotary shaft performance test.

- Drawbar performance test.
- Parking brake test.
- Noise measurement.
- Air cleaner oil pull over test.
- Mechanical vibration measurement.
- Turning ability test.
- Chemical composition test and wear characteristics test of rotavator blades.

Field tests: For Initial commercial tests & batch test 35 h, of field tests with the following implements

- Mould board ploughing (20 hrs. for I.C.T. only) dryland
- Dry rotavation (35 hrs. for I.C.T. & 35 hrs. for Batch tests)
- Puddling under actual field condition (15 h for I.C.T. & Batch test both)

Haulage test: Components and assembly inspection is done to assess the wear, breakdowns, etc.