

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*.

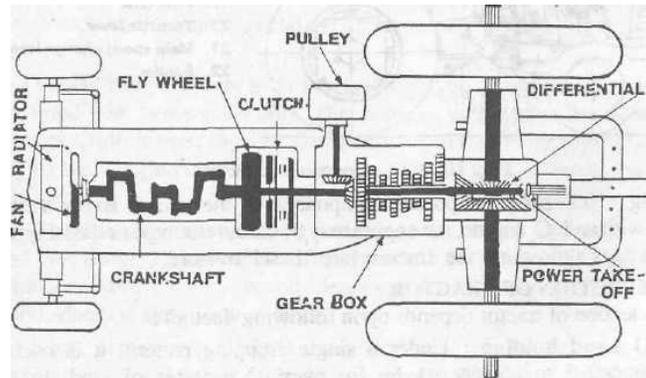


Fig 1 Power Transmission system of Tractor

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, (ii) 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 AND FLUID COUPLING 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:

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

TYPES OF CLUTCH

(1) Friction clutch (2) Dog clutch (3) Fluid coupling.

FRICITION 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 lo larger surface area of friction members.

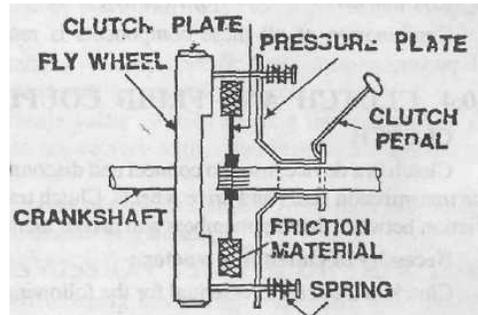


Fig. 2 Single plate clutch

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.

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 entire 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.

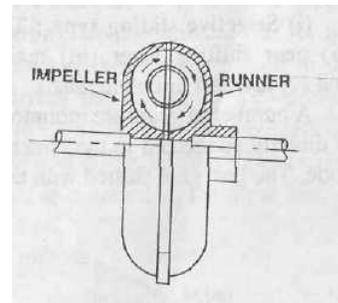


Fig 3 Fluid coupling

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

$$BHP = \frac{2\pi NT}{4500}$$

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. Common gears used on tractors are of two types:

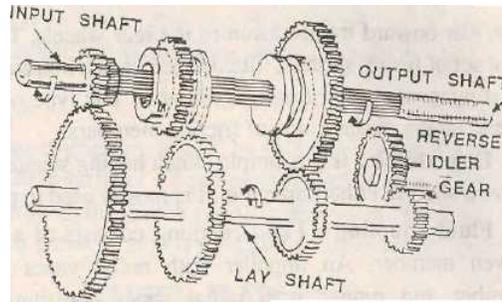


Fig 4 Transmission gears

(i) Selective sliding type (ii) Constant mesh type.

(i) Selective sliding type: The gear box consists of: (i) gear housing (ii) gear shifting lever (iii) main shaft or input shaft (iv) output shaft and (v) lay shaft or countershaft.

A number of gears are mounted on these shafts (Fig. 5). The main shaft is directly connected to the clutch and carries gears. The gears are liable to slide. The gears are shifted with the help of shifting lever and shifting fork.

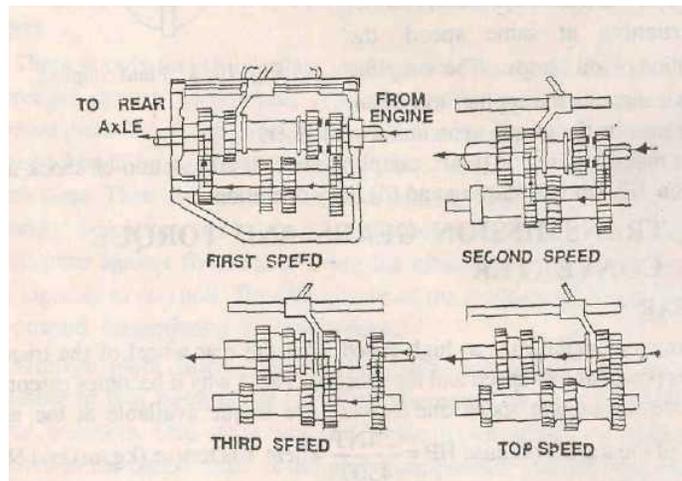


Fig 5 Sliding type gearbox for 4 speeds

The gears are shifted along the shaft, to which they are splined to engage with another gear as and when desired to connect the power train. The gears are of different diameters having different number of teeth. Speed is reduced in proportion to the number of teeth provided on the gears.

(ii) Constant mesh type: These gears are always in mesh. Usually the gears are helical in shape. The transmission is put into operation by engagement of shifting couplings, which slide along the splines on the countershaft and the output shaft of the gear box.

DIFFERENTIAL UNIT AND FINAL DRIVE

Differential: *Differential unit* is a special arrangement of gears to permit one of the rear wheels of the tractor to rotate slower or faster than the other. While turning the tractor on a curved path, the inner wheel has to travel lesser the tractor to move faster than the other at the turning point. The output shaft coming from the gear box is provided with a bevel pinion at the end of the shaft (Fig. 6). The bevel pinion is in mesh with a large bevel wheel known as *crown wheel*. The main functions of *crown wheel* assembly are:

- (i) to transmit power through right angle drive to suit the tractor wheels.
- (ii) to reduce the speed of rotation.

The differential unit consists of: (i) differential casing (ii) differential pinion (iii) crown wheel (iv) half shaft and (v) bevel gear.

The differential casing is rigidly attached with the crown wheel and moves like one unit. Two pinions are provided inside the differential casing, such that they are carried round by the crown wheel but they are free to rotate also on their own shaft or stud. There are two or more bevel gears in mesh with differential pinion. One bevel pinion is at the end of each half shaft, which goes to the tractor rear wheel. Thus instead of crown wheel being keyed directly to a solid shaft between the tractor wheels, the drive is taken back from the indirect route through differential casing, differential pinion and half shaft of the tractor. When the tractor is moving in a straight line, the differential pinion do not rotate on the stub shaft but are solid with the differential casing. They drive the two bevel gears at the same speed and in the same direction as the casing and the crown wheel.

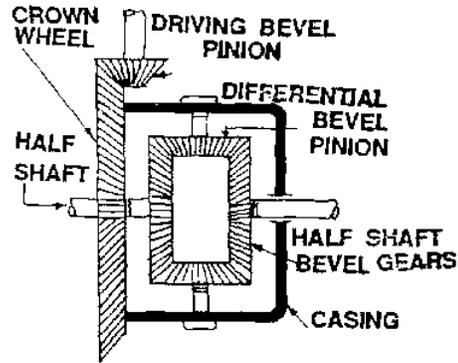


Fig. 6 Differential unit

Each differential pinion can move in two planes simultaneously. When it is carried round by the casing, it drives the half-shaft in the same direction but when it is rotated on its own shaft, it drives them in opposite direction i. e. rotation of differential pinion adds motion to one shaft and subtracts motion from the other shaft.

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 wheels is known as final drive mechanism.

STEERING SYSTEM AND BRAKE STEERING SYSTEM

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: (i) steering wheel (ii) steering shaft (iii) steering gear (iv) pitman arm (drop arm) (v) drag link (vi) steering arm (vii) tie rod and (viii) king pin.

When the operator turns the steering wheel, the motion is transmitted through the steering shaft to the 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 king pins 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 (Fig. 7).

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.

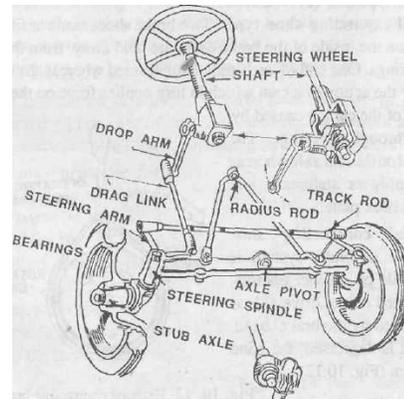


Fig. 7 Steering system

BRAKE

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 element 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 (a) Internal expanding shoe type (b) External contracting shoe type and (c) Disc type and (2) Hydraulic brake.

(a) **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 fulcrumed 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.

(b) **External contracting shoe type:** This type of brake system is normally available on crawler tractors. The drum mounted on the drive axle is directly surrounded by the brake band. When the pedal is depressed, the band tightens the drum (Fig. 8).

(c) **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 travelling 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 glycerine and alcohol is filled in the master cylinder (Fig. 9). When the pedal is depressed, the piston of the master cylinder is forced into the cylinder and the entire 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 original position, causing a sudden pressure drop in the line. The retracting springs of the brake shoe bring them back to their original position. Thus the piston of the wheel cylinder returns back.

HYDRAULIC CONTROL SYSTEM

It is a mechanism in a tractor to raise, hold or lower the mounted or semi-mounted equipments by hydraulic means.

Working principle: The working principle of hydraulic system is based on Pascal's law. This law states that the pressure applied to an enclosed fluid is transmitted equally in all directions. Small force acting on small area can produce higher force on a surface of larger area.

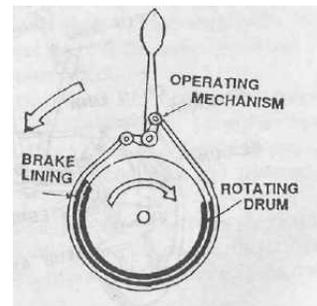


Fig. 8 External contracting brake shoe

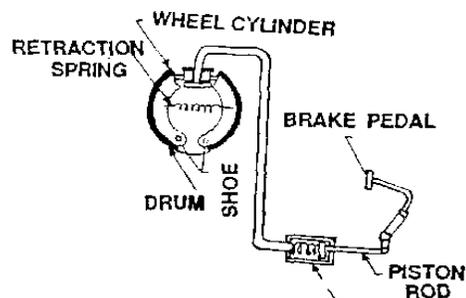


Fig. 9 Hydraulic Brakes

A simple hydraulic system consists of a pump which pumps oil to a hydraulic ram. This pump may be driven from tractors transmission system or it may be mounted on its engine. This system consists of a cylinder with a close fitting piston like an engine cylinder. As the oil is pumped into the closed end of the cylinder, the piston is forced along with it. The movement of the piston is transmitted to the lower links by means of a cross shaft and lift rods. A control valve controls the flow of oil and directs it back to the reservoir. It allows the oil in the cylinder to flow out again when the links are to be lowered. It also traps the oil in the cylinder when the links are to be held at any height.

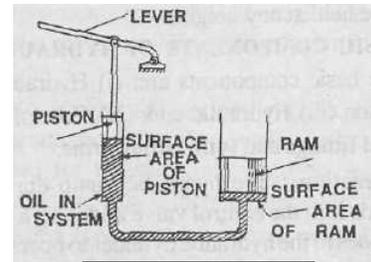


Fig 10 Pascal Law

BASIC COMPONENTS OF HYDRAULIC SYSTEM

The basic components are: (i) Hydraulic pump (ii) Hydraulic cylinder and piston (iii) Hydraulic tank (iv) Control valve (v) Safety valve (vi) Hose pipe and fittings and (vii) Lifting arms.

Operation: The hydraulic pump draws up oil from the oil reservoir and sends it to the control valve under high pressure. From the control valve, the oil goes to the hydraulic cylinder to operate the piston, which in turn, raises the lifting arms. The lifting arms are attached with implements. The hydraulic pump is operated by suitable gears, connected with engine.

There are two types of arrangements for storing hydraulic oil in the system : (i) There is a common oil reservoir for hydraulic system and the transmission system in some tractors, (ii) There is a special tank for hydraulic oil. It is separate from' the transmission chamber.

TRACTOR HITCH

Implements are needed to be hitched properly for efficient and safe operation of the tractor. Implements can be; (i) Trailed (ii) Semi mounted and (iii) Mounted. Implements can be hitched in two ways: (a) Drawbar hitch and (b) Three point linkage.

Drawbar hitch: Drawbar is a device by which the pulling power of the tractor is transmitted to the trailing implements. It consists of a crossbar with suitable holes, attached to the lower hitch links. It is fitted at the rear part of the tractor.

Three point linkage: It is a combination of three links, one is upper link and two are lower links, the links articulated to the tractor and the implements at their ends in order to connect the implement to the tractor.

Advantage of three point linkage ; (1) Easy control of working implements (2) Quick setting of implements (3) Automatic hydraulic control of implements such as position control, draft control etc. (4) Good balancing of attached implements.

POWER TAKE-OFF UNIT (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. In order to operate 1000 rpm PTO drive machine, a new standard has been developed.

BELT PULLEY

All tractors are provided with a belt pulley. The function of the pulley is to transmit power from the tractor to stationary machines by means of a belt. It is used to operate thresher, centrifugal pumps, silage cutter and several other machines. The pulley is located either on the left, right or rear side of the tractor. The pulley drive is engaged or disengaged from the engine by means of a clutch. The pulley is generally made of cast iron.