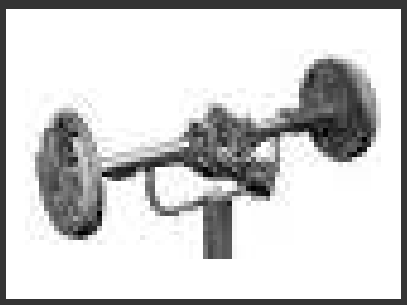

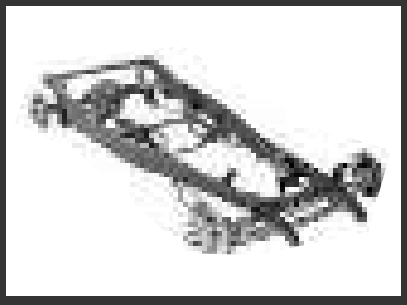

TWO COLOUR EDITION

A text book on

TRACTOR SYSTEM AND CONTROL

S. B. Patil
P. R. Sapkale
T. B. Bastewad
A. N. Shinde

Aditi Prakashan

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TRACTOR SYSTEM AND CONTROL

Tex Book for **FMP-248**

Also useful for GATE ,ICAR-JRF Entrance Examination, ASRB-NET Public Service Commission Examination, and many other Exminations.

Reference book for **ENGG-353**

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First Edition

January - 2013

Publisher :
Aditi Prakashan
A/P: Bhadole Tal: Hatkanangale
Dist: Kolhapur-416112

Copies :
1000

Price:
Rs. 200/-

Printed at :
Shri Ganesh Printing Press
Peth vadgaon Tal: Hatkanangale
Dist: Kolhapur-416112

Contact for availability of book

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PREFACE

The book is primarily prepared for undergraduate Agricultural Engineering students for the course number FMP-248 and is based on the syllabus approved by the IVth dean committee and also can be very useful for the course number ENGG-353 of B. Sc. (Agri.). This book will be very useful for preparation of Mid-semester, Semester End (Theory + Practical) Examinations of the said course numbers and also will be helpful for the preparation of GATE, ICAR-JRF Examination, ASRB-NET, Public Service Commission Examinations, and many other examinations based on the syllabus.

All the chapters are prepared in a well explained and easily understandable manner to the students. Some numericals are also worked out to master the students in the subject. The objective type questions which are compulsory part of semester end examinations and in many common entrance tests also important for exhaustive knowledge of the chapters are included at the end of each chapter.

To understand the concepts easily, the diagrams are prepared in a very simple manner so that students can understand it and draw in the examination. To help the easy reading and fast understanding the printing of the book is made in two colors.

We hope this book will help the students in their undergraduate courses and also for preparing many of the entrance and competitive examinations. We wish all the readers very bust luck.

S. B. Patil
P. R. Sapkale
T. B. Bastewad
A. N. Shinde

ACKNOWLEDGEMENT

We sincerely express on thanks to all who are directly or indirectly helped and co-operated for writing, manuscript checking, designing, typing, printing and to all the sponsors for partial monitory support or the books.

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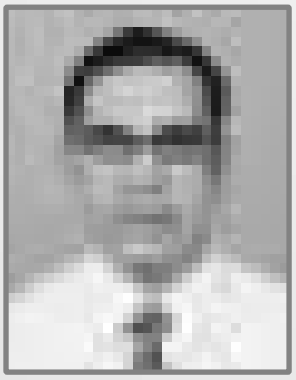

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- He has received First award in 2007 from Baliraja Magazine for science based writing.
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- He has authored two books in marathi language one for farmers 'Shrtiche Yantrikikaran ani Aujare' and another for Agriculture Technical School ' Krushi Aujare, Yantre ani Adhunik sinchan Paddhati' as a text book. And one Book entitled 'Farm Power' for the B. Tech. (Agril. Engg.) Students.
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- He has experienced in the field of Farm Power and Machinery especially in training and testing of Tractor and Agricultural Machinery in national Institute of Central Farm Machinery Training and Testing Institute, Tractor Nagar, Budni (MP).
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- He has completed various training programs in various technical subjects from different reputed institutes.
- He has delivered several radio talks on various topics.
- He is a Member of IAP.

CONTENTS

Chapter

1

CLUTCH

Contents:

A Clutch is a machine member used to connect the driving shaft to a driven shaft. A clutch thus provides an interruptible connection between two rotating shafts.

It is a coupling used for connecting or disconnecting the engine power to gear box. The clutch is fitted in between engine & gear box.

1.1 The main functions of clutch are:

i) To disconnect the engine power from gear box as & when required.

ii) To allow the engine to take up the load gradually without shock.

1.2 Essential features of clutch

1. It should have good ability of taking load smoothly without dragging and Chattering.
2. It should have higher capacity to transmit maximum power without slipping.
3. Friction surface should be highly resistant to heat effect.
4. The control should be easy and require little pedal pressure to operate.
5. It should be easy to adjust and overhaul.

1.3 Principle of operation of clutch

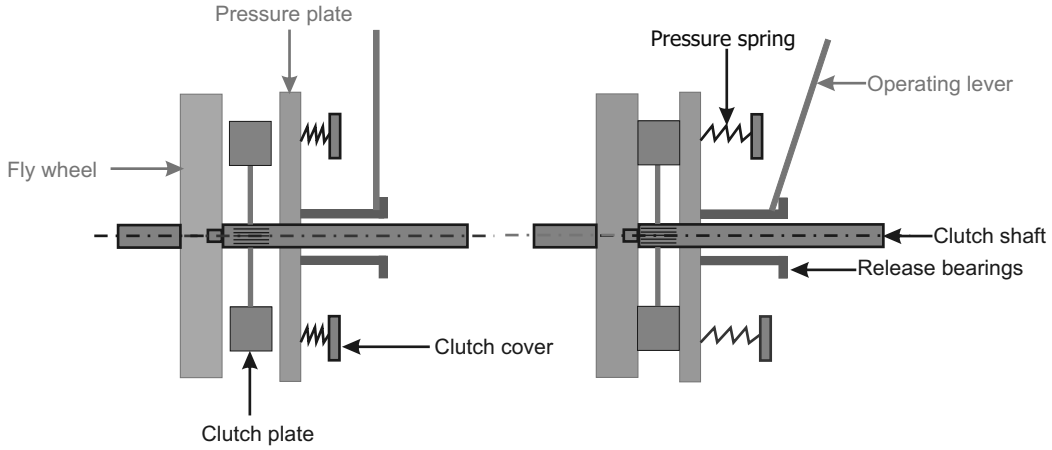


Figure 1.1 Principle of operation of clutch

- The clutch works on the principle of **friction**, in which when one stationary surface is brought into contact with a rotating surface, the stationary surface also starts rotating.
- Consider, a driven plate mounted on a transmission shaft is enclosed between two driving plates.
- **When driving plates are away**, they will rotate together but driven plate will remain stationary.

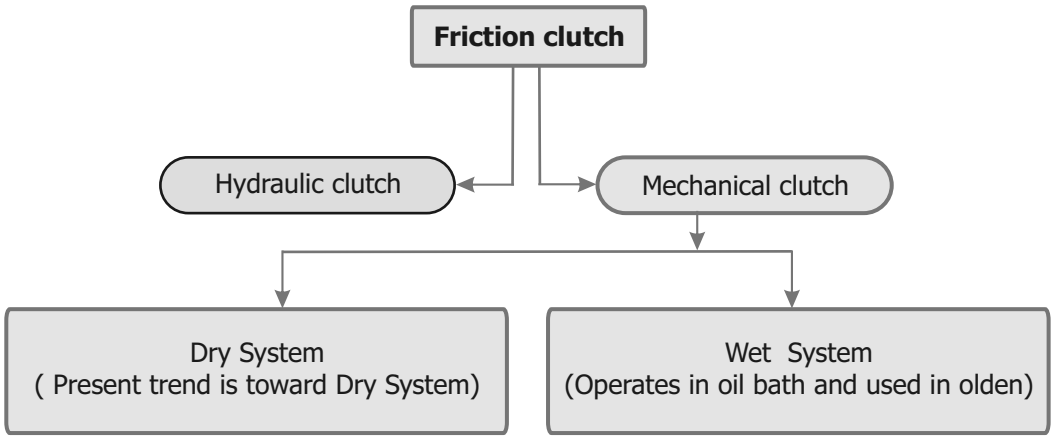
- Now, if by some means, two driving plates are brought nearer, the driven plate will be pressed in between two rotating plates & will bound to rotate together as one unit.
- In actual practice one of driving plates is the flywheel & other is known as pressure plate.
- The driven plate is a clutch plate, made of the frictional material & directly mounted on the **splined end of clutch shaft.**
- **In normal running condition,** the pressure springs keep pressure plate in contact with clutch plate.
- **When clutch pedal is depressed,** the pressure plate moves away against pressure of springs allowing clutch plate & thus clutch shaft to become Stationary.

1.4 Different types of clutch (Classification)

Clutches are mainly of three types:

A. Friction clutch :-

Most popular in Four wheel tractors and are further subdivided as:



B. Dog Clutch :-

- Mostly used in Power Tillers.
- It has square jaws to drive the shaft.
- It is used to drive shaft in either direction.

C. Fluid Coupling :-

1.5 Working of single plate clutch system

- The main components of single plate clutch system are :

a) A Clutch Plate
b) Pressure Plate
c) Clutch Cover
d) Pressure Springs
d) Pressure Springs
e) Release Finger
f) Release Bearings
g) Clutch Shaft
h) Linkage

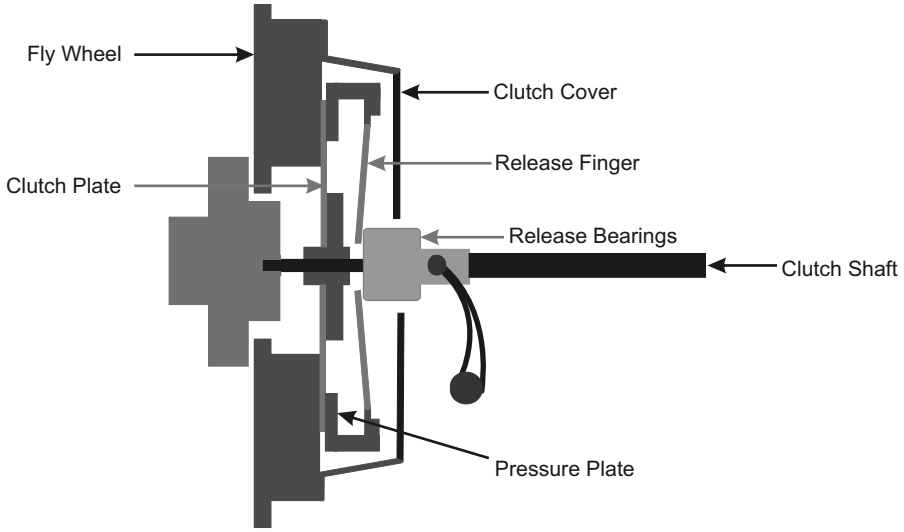


Figure 1.2 Working of single plate clutch system

- As shown in fig. 1.2 clutch cover is bolted to flywheel & clutch plate is mounted on splined part of clutch shaft.
- The front end of clutch shaft is freely supported on pilot bearing fitted in fly wheel & other end passes through release bearing.
- In between pressure plate & clutch cover pressure springs are placed all around the circumference.
- **Three fingers** (also known as release levers) are centrally fulcrumed to the clutch cover and their outer ends connected to pressure plate.
- A release bearing slightly away from free ends of fingers is connected to clutch pedal through linkage.
- **As soon as clutch pedal is depressed,** release bearing moves towards the fly wheel & presses the fingers inside (i.e. towards flywheel).
- As soon as free ends of fingers press inside by release bearing, the outer ends tend to bring the pressure plate against the pressure springs (i.e. away from flywheel). , making the clutch plate & clutch shaft disengaged and stops rotations of clutch plate, but the pressure plate & cover remain rotating along with fly wheel.
- Thus, the condition of disengagement of clutch plate & clutch shaft remain till ` foot pedal remains dispersed.
- **When the force on the foot pedal is released,** the pressure springs moves the pressure plate ahead (i.e. towards flywheel) to press the clutch plate in between flywheel and pressure plate and causes a clutch plate, pressure plate and flywheel to turn together as one unit.

1.6 Different parts of clutch system.

1.6.1 Clutch plate:

Two types of clutch plates are found on tractors,

a) Solid hub type b) Flexible hub type

Solid hub type	Flexible hub type
The hub & plate are fastened together securely & there is no movement in unit	The flexible hub has torsion springs & friction disc between plate & hub.
These are plane with no dishing	These are slightly dished when manufactured. Sometimes instead of dishing plates cushion springs are utilized

1.6.2 Pressure plate:

- Pressure plate assembly consists of a steel cover & a pressure plate loaded with a number of thrust springs.
- The pressure plate carries three release levers.
- The pressure plate is made of special cast iron to resist heat developed due to slipping of clutch plate when clutch is engaged.
- It presses the clutch plate against the flywheel by the force of compression springs.

1.6.3 Clutch shaft :

- The front end of the shaft is smaller in dimension & is supported on the pilot bearing in the engine crankshaft flange.
- On the splinted part of the shaft, the clutch disc moves.

1.6.4 Pilot bearing :

This may be a self - lubricated sealed ball bearing or a needle bearing.

1.7 Working of duel plate clutch system.

- Some of the tractors are provided with two clutch plates one for the main transmission & the other for PTO drive.
- In between the two clutch plates, an intermediate plate is provided.
- Normally, three release levers serve the purpose of disengaging the clutch plates. However, some of the tractors have six releases levers, three each for the main drive & PTO drive.
- Engagement and disengagement of this type of clutch is very smooth due to larger surface area of friction members.
- Because of large surface area of friction members it engages smoothly.

1.8 Clutch adjustment

- Due to long time use, the clutch facing gets worn out. Similarly when the clutch has been abused or used wrongly, facing gets worn out quickly.
- Hence the distance between pressure plate and flywheel reduces, this results in increase in distance between release bearing and fingers.
- Under these circumstances when the clutch pedal is pressed the release bearing can not press the fingers to the required distance, hence the clutch plate does not disengage properly. Hence clutch adjustment is essential.
- The only normal adjustment required throughout the life of clutch friction lining is to readjust the free movement of the clutch pedal periodically i.e. "movement of pedal before release bearing comes in contact with the fingers."
- The clutch free play is related with the clearance between the release bearing & fingers.
- On some tractors, this clearance is adjusted by linkage, whereas on others it is adjusted by moving clutch release shaft.

1.9 Trouble shootings

1.9.1 Clutch Drags

(When pedal is depressed to disengage the system, even then driven plate rotates).

Possible cause		Remedy
• Dirt or other foreign material in the clutch plate.	---	Clean.
• Improper pedal adjustment	---	Adjust clutch pedal free play.
• Warped clutch plate.	---	Replace new lining.
• Damaged pressure plate or clutch cover.	---	Install new parts.
• Splines of the shaft tight or burred.	---	Clean and smear with grease.

1.9.2 Clutch Slippage

(lack of firm contact between flywheel , pressure pate and clutch plate is known as slip)

Possible cause		Remedy
• Oil or grease on the lining.	—	Clean with the petrol or replace.
• Glazed surfaces of lining caused due to constant rubbing of dust particles.	---	Replace new lining.
• Bent or tight release shaft.	---	Straighten and free the shaft.
• Lack of clutch free play.	---	Adjust.
• Worn out lining.	---	Replace.
• Uneven adjustment of release levers (fingers).	---	Adjust properly.
• Weak pressure spring.	---	Fit new set of springs.

1.9.3 Clutch Grabs

(during engagement of the clutch vehicle moves with series of jerks).

Possible cause		Remedy
• Oil or grease on the lining.	---	Clean
• Glazed lining.	---	Replace
• Damaged pressure plate	---	Replace
• Splines of the shaft or clutch plate tight or burred	---	Clean and smear with grease.
• Bent or tight release shaft.	—	Straighten and free the shaft.

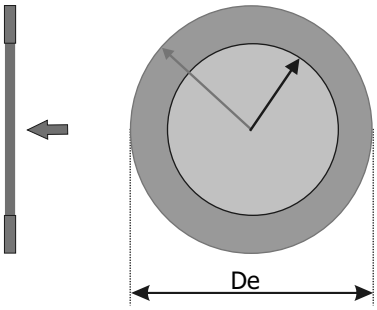
1.9.4 Clutch Noises

Possible cause		Remedy
• Weak or broken pressure springs	---	Replace affected springs.
• Excessive worn splines on the shaft and clutch plate	---	Replace affected parts.
• Worn or dry release bearings/pilot bearings	---	Replace affected parts.

1.9.5 Abnormal lining wear

Possible cause		Remedy
• Insufficient pedal free play	---	Adjust
• Overriding of the clutch pedal.	---	Caution the operator to avoid this.
• Weak/broken pressure spring incapable of pressing the pressure plate against clutch plate	---	Replace.
• Warped pressure plate.	---	Replace.
Incorrect adjustment of clutch fingers	---	Adjust properly.

1.10 Design of disc or plate clutch



1.10.1 Torque:

In case of friction brakes, torque is given by:

$$T = \mu * W * r_m * n$$

Where,

μ = Coefficient of friction.

W = Axial thrust with which friction surfaces are held together. or clamping force.

r_m = Mean radius of friction surface (clutch lining).

n = Number of torque transmitting surfaces.

(In case of single disc or single plate clutch plate, both sides of clutch plate are effective hence, number of torque transmitting surfaces = 2).

Note: Number of torque transmitting surfaces $\mathbf{n = n_1 + n_2 - 1}$

Where,

n_1 and n_2 = Number of driving and driven discs respectively.

1.10.2 Mean radius of clutch facing:

There are two theories concerning the torque required to produce slip between the surfaces of a clutch. One theory assumes the pressure is even over the surface of contact and the other theory assumes that wear is uniform.

a) Considering uniform pressure:

When the pressure is uniformly distributed over the entire area of friction face, mean radius of friction surface (clutch lining) is given by:

$$r_m = \frac{2}{3} * \left[\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2} \right]$$

b) Considering uniform wear:

$$r_m = \frac{r_o + r_i}{2}$$

1.10.3 Intensity of pressure:

Let 'p' be the normal intensity of the pressure acting at a distance 'r' from the axis of the clutch.
Since the intensity of the pressure is inversely proportional to a distance,

Therefore,

$$p * r = C \text{ (Constant)}$$

The intensity of the pressure is maximum at inner radius of the friction surface, Hence,

$$p_{max} * r_i = C \qquad \text{i.e.} \qquad p_{max} = C / r_i$$

The intensity of the pressure is minimum at outer radius of the friction surface, Hence,

$$p_{max} * r_o = C \qquad \text{i.e.} \qquad p_{max} = C / r_o$$

And average pressure 'p_{av}' on friction surface is given by:

$$p_{av} = \frac{\text{Total force on friction surface}}{\text{Cross sectional area of friction surface}} = \frac{W}{\Pi (r_o^2 - r_i^2)}$$

Note : The uniform pressure theory gives higher friction torque than the uniform wear theory.
Therefore in case of friction clutches, uniform wear should be considered, unless otherwise stated.

1.10.4 Total force on contact surface of the clutch plate:

It is known as axial force or axial load and can be calculated by:

$$W = p(2 * Л * r)(r_o - r_i)$$

$$W = 2 * Л * C * (r_o - r_i) \qquad \text{---- } (p * r = C)$$

NUMERICALS:

1.1 A single plate clutch with both sides effective has an outer diameter of 30 cm and inner diameter of 20 cm. The maximum intensity of pressure at any point in the contact surfaces does not exceed 1 Kg/cm^2. If the coefficient of friction is 0.3, determine the power transmitted by clutch operating at 2000 rpm speed.

Answer:.

Data: $D_o = 30$ cm i.e. $r_o = 15$ cm $\quad D_i = 20$ cm i.e. $r_i = 10$ cm $\quad p = 1$ Kg/cm^2 and $\mu = 0.3$

We have, $C = p_{max} * r_i$

$= 1 * 10$

$C = 10$

Also, $W = 2 * Л * C * (r_o - r_i)$

$= 2 * 3.142 * 10\ (15-10)$

$W = 314.2$ Kg

And $r_m = \dfrac{r_o + r_i}{2}$

$= (15+10)/2$

$r_m = 12.5$ cm.

Now, Torque, $T = \mu * W * r_m * n$

$= 0.3 * 314.2 * 12.5 * 2$

$= 2356.5$ Kg-cm

$T = 23.565$ Kg-m

And Power P $= (2 * Л * N * T) / 4500$

$= (2 * 3.142 * 2000 * 23.565) / 4500$

$=$ **65.81 Hp**

1.2 Calculate maximum, minimum, and average pressure of cultch plate, when axial is 6 KN. Assume inside and outside radius of contact surface is 6 and 12 cm, respectively. Wear is uniform.

Answer:

Data: $r_o = 12$ cm $r_i = 6$ cm and $W = 6 X 10^3$ N

We have, $C = p_{max} * r_i$

$= p_{max} * 6$

And,

$W = 2 * Л * C * (r_o - r_i)$

$6 X 10^3= 2 * 3.142 * 6\, p_{max} * (12 - 6)$

$6000 = 226.22\, p_{max}$

$p_{max} = 6000/226.22$.

$p_{max} =$ **$26.52\ N/cm^2$**

Maximum pressure of cultch plate, $p_{max} = 26.52\ N/cm^2$ ----- (1)

Also,

We have, $C = p_{min} * r_o$

$= p_{min} * 12$

And,

$W = 2 * Л * C * (r_o - r_i)$

$6 X 10^3 = 2 * 3.142 * 12\, p_{max} * (12 - 6)$

$6000 = 452.44\, p_{max}$

$p_{max} = 6000/226.22$

$P_{max} =$ **$13.26\ N/cm^2$**

Minimum pressure of cultch plate, $p_{min} = 13.26\ N/cm^2$ ----- (2)

Now, average pressure 'p_{av}' on friction surface is given by:

$$p_{av} = \frac{\text{Total force on friction surface}}{\text{Cross sectional area of friction surface}} = \frac{W}{\Pi (r_o^2 - r_i^2)}$$

$$= \frac{6000}{[3.124 * (12^2 - 6^2)]} = \frac{6000}{339.336} = \mathbf{17.68\ N/cm^2}$$

Average pressure of cultch plate, $p_{av} = 17.68\ N/cm^2$ ----- (3)

1.3 A single plate friction clutch with both sides effective transmits 20 kW power at 2000 rpm. The axial pressure is limited to 0.1 N/mm^2. If the outer diameter of the friction lining is 1.5 times of inner diameter, design suitable dimensions of friction lining. The coefficient of friction may be 0.3. Assume uniform wear condition.

Answer:

Data: $D_o = 1.5\, D_i$ i.e. $r_o = 1.5\ r_i$, $p_{max} = 0.1\ N/mm^2$ $n = 2$, $\mu = 0.3$ and $N = 2000$ rpm,

$$r_m = \frac{R_o + r_i}{2} = \frac{(1.5 * r_i) + r_i}{2} = \mathbf{1.25\, r_i}$$

We have, $C = p_{max} * r_i$

$= \mathbf{(0.1 * r_i)\ N\text{-}mm.}$

And,

$W = 2 * \Pi * C * (r_o - r_i)$

$= 2 * 3.142 * 0.1 * r_i * (1.5\, r_i - r_i)$

$W = \mathbf{0.3142\, r_i^2\ N}$

Also, Torque, $T = \mu * W * r_m * n$

$= 0.3 * 0.3142\, r_i^2 * 1.25\, r_i * 2$

$= \mathbf{0.2356\, r_i^3\ N\text{-}mm}$

$T = \mathbf{0.2356\, r_i^3 \times 10^{-3}\ N\text{-}m}$

Power, P = (2 * Л * N * T) / (60 * 1000)

20 = (2 * 3.142 * 2000 * T) / 60000

T = **(20 * 60000)/ (2 * 3.142 * 2000)**

Hence,

0.2356 $r_i^3 \times 10^{-3}$ = (20 * 60000)/ (2 * 3.142 * 2000)

0.2356 $r_i^3 \times 10^{-3}$ = 95.480

r_i^3 = 95.480/(0.2356 $\times 10^{-3)}$

r_i = **73.97 mm**

Hence, r_o = 1.5 r_i = 1.5 * 73.97

r_o = **110.955 mm.**

1.4 . How much maximum torque can be transmitted by a clutch plate of 200 mm internal diameter and 250 mm external diameter? Assume coefficient of friction as 0.4 and clamping force to be 100 N.

Answer:

Data: D_o = 250 mm i.e. r_o = 125 mm, D_i = 200 mm i. e. r_i = 100 mm, n = 2, μ = 0.4 and W = 100 N.

We have,

$$r_m = \frac{r_o + r_i}{2} = \frac{125 + 100}{2} = \mathbf{112.5\ mm}$$

Torque, T = μ * W * r_m * n

= 0.4 * 100 * 112.5 * 2

= **9000 N-mm**

= **9.0 N-m**

Hence, maximum torque can be transmitted by a clutch plate = = **9.0 N-m**

QUESTIONS

Q. 1 What is clutch? Explain main functions of clutch.

Q. 2 What are the essential features of clutch?

Q. 3 Explain principal of operation of clutch with neat diagram.

Q. 4 What are the different types of clutch? OR How clutches are classified?

Q. 5 Explain working of single plate clutch system with neat diagram.

(Sem. End. Exam. 2008-09, 2009-10, 2010-11)

Q. 6 Write a short note on different parts of clutch system.

Q. 7 Explain working of dual plate clutch system. (Sem. End. Exam. 2011-12)

Q. 8 What is clutch adjustment? Why it is needed?

Q. 9 Explain the trouble shootings in clutch.

OBJECTIVE QUESTIONS

A) Fill in the Blanks:

1. The clutch is fitted in between ---- & ----
2. The clutch works on the principle of ----
3. In single plate clutch system one of driving plates is the fly wheel & other is k n o w n as ----
4. In single plate clutch system the driven plate is a ----
5. In two disc clutch one plate is for main transmission & other for ----
6. Generally ---- type of clutches are used on tractors.
7. To compensate clutch friction lining ---- adjustment is done.
8. ---- type clutch plates have torsion springs between friction disc and hub.
9. Dog clutch is mainly used in ----
10. Friction clutch is used where drive speed is ---- rpm.
11. Multiple disc type clutches may be of ---- type.

B) Multiple choice questions:

1. In normal running, the ---- keep the pressure plate in contact with clutch plate.
   a) Pressure springs
   b) Release bearing
   c) Clutch cover
   d) Release fingers
2. The clutch free play is related with the clearance between the ---- & ----
   a) Flywheel and clutch plate
   b) Release bearing and release fingers
   c) Clutch plate and pressure plate
   d) Pressure plate and flywheel
3. Dog clutch is used to drive the shaft in ---- direction.
   a) Clockwise
   b) None of these
   c) Anticlockwise
   d) both (a) and (b)
4. Pressure springs are provided between ----- & -----
   a) Flywheel and clutch cover
   b) Release bearing and clutch cover
   c) Clutch plate and pressure plate
   d) Pressure plate and clutch cover
5. Cushioning springs in a clutch plate are meant for ----
   a) Torsional vibrations
   b) Jerky starts
   c) vehicle speed
   d) none of above

ANSWERS

A) Fill in the Blanks:

1. engine & gear box.
2. Friction
3. pressure plate.
4. clutch plate
5. power take off (PTO).
6. Friction.
7. free play
8. Flexible hub
9. Power tiller3
10. 2000
11. Wet.

B) Multiple choice questions:

1. Pressure springs
2. Release bearing and release fingers.
3. both (a) and (b)
4. Pressure plate and clutch cover
5. Jerky starts

Chapter
2

GEAR BOX

Contents:

Gearbox plays an important role in power transmission system. It is meant to change the shaft direction, changing speed and for transmitting power.

The horsepower delivered to the rear wheels depends upon the turning effort & the speed of rotation. Mathematically, it is represented as,

$$\text{Horsepower, (Hp)} = \frac{2 \times \text{Torque (kg-m)} \times \text{N (rpm)}}{4500}$$

If the engine horsepower is constant, from the above relation it is obvious that for higher torque at wheels, low speed is required & vice-versa.

Hence, the gearbox is incorporated in-between the engine & rear wheels as a solution for the variable torque & speed.

2.1 Need of gear box in tractors.

- The tractive effort required on rear wheels varies with the magnitude of the load being pulled & soil characteristics.
- If the tractor engine power is delivered to the rear wheels directly through a set of bevel gears at right angles, the tractor will run at constant speed, which obviously, will be very high & a fixed tractive effort will be available at the rear wheels.
- In tractors, the driving wheels require power supply at low rpm and high torque, whereas the engine runs at high rpm and low torque.
- Hence, some means have to be introduced between engine & rear wheels where high speed of engine could be reduced for torque multiplication to achieve desired tractive effort.
- Thus, a gear box serves the purpose of reduced wheel speed & variable tractive effort.

2.2 Principle of gearing

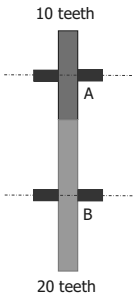


Fig. 2.1 (a)

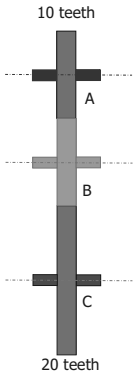


Fig. 2.1 (b)

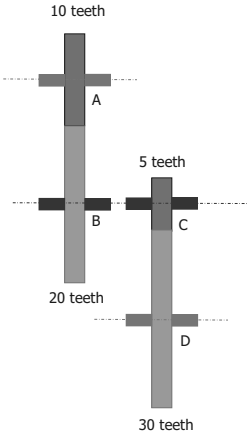


Fig. 2.1 (c)

Figure 2.1 Principle of gearing

- Any combination of gear wheels by means of which motion is transmitted from one shaft to another shaft is called a gear train.

- Consider a single train in which the driving gear A has 10 teeth & driven gear B has 20 teeth. Fig 2.1 (a) If gear A is rotating with a speed of 100 rpm, the speed of gear B is given by :

$$\frac{\text{Speed of driving gear } (N_A)}{\text{Speed of driving gear } (N_B)} = \frac{\text{No. of teeth on driven gear } (T_B)}{\text{No. of teeth on driven gear } (T_A)}$$

$$\text{or Speed of driven gear } (N_B) = = \frac{100 \times 10}{20} = 50 \text{ rpm}$$

- This shows that if the number of teeth on driven gear is doubled, the speed becomes half of the driving gear.

- However,

$$\text{Power} = \frac{2\ N_A\ T_A}{4500} = \frac{2\ N_B\ T_B}{4500}$$

Putting the values of N_A, T_A & N_B

$$T_B = \frac{[100 \times T_A]}{50}$$

$$T_B = 2\ T_A$$

The torque of gear B (T_B) will be twice, that of gear A (T_A).

- The direction of rotation of gear B will be opposite to that of gear A. However, if an additional gear is mounted or introduced (fig. 2.1 (b)) or a compound gear (fig. 2.1 (c) the direction of final gear will be the same as that of the driving gear.

- The speed of the final driven gear will depend upon the product of the gear ratio of each pair.

$N_A/N_B = T_B/T_A$ & NC/ ND = TD/TC

Also, Gear B and gear C are mounted on same shaft, $N_B = NC$

$$\frac{N_A}{N_D} = \frac{N_A}{N_B} \times \frac{N_c}{N_D} = \frac{T_B}{T_A} \times \frac{T_D}{T_C}$$

2.3 Different types of gear box available on tractors

There are three types of gear boxes available on tractors, namely

1) Sliding mesh 2) Constant mesh 3) Synchromesh gear box.

2.3.1 Sliding mesh gear box

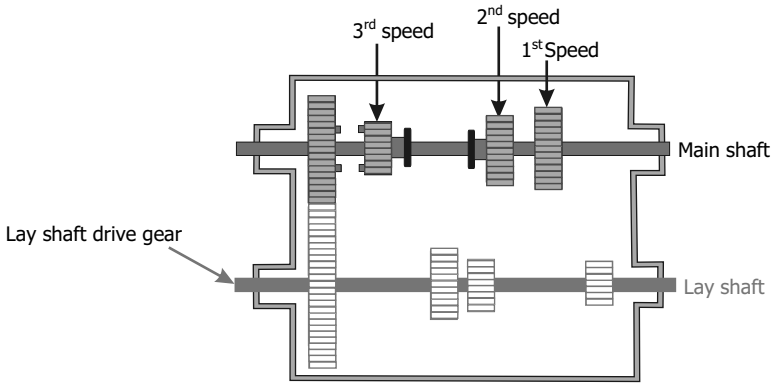


Figure 2.1 Three speed sliding mesh gear box

- Most of the indigenous tractors are fitted with a sliding mesh or sliding mesh type gear box.
- Usually, the main & counter shafts are parallel to the clutch shaft, in addition to the two shafts, a third shaft carries reverse gear.
- The **upper shaft** is known as the **main shaft** & the **lower** one is known as **counter shaft or lay shaft**.
- The gears on lay shaft are fixed, whereas, those on the main shaft slide to mesh with a suitable gear on the countershaft.

- Gearshift rails & forks are used to shift gears from one position to another.
- In order to allow only one pair of gears to engage at one time, the shift rails are kept in position with the help of spring loaded detent balls or by another device.
- This can provide 3-4 forward and one reverse speed.
- **Advantages:**
    1. It has highest transmission efficiency.
    2. It is simple in design.
    3. It is cheaper in cost
- **Limitations:**
    1. It is limited to small size tractors only.
    2. Large gears are hard to move.
    3. Larger teeth cause interference in engagement and the teeth can be damaged during shifting.
    4. Tractor needs to be stopped before gear shifting to avoid teeth damage.

2.3.2 Constant mesh gear box

- The constant mesh transmission is similar to sliding mesh type gear box except the **gears on main shaft and counter shaft are in constant mesh**.
- The gears on the main shaft are mounted on bushings & are free to rotate along with the counter shaft gear without affecting the main shaft when in neutral.
- The engagement and disengagement is achieved by splined sleeve couplings operated by gear lever.
- **When the gear lever is engaged**, the coupling devices move from one side to another to lock a free gear on the main shaft.
- Thus the main shaft gets drive through the driven gear & coupling unit.
- This type of gear transmission is slightly less efficient than sliding mesh type due to friction between rotating gears and shafts.
- Tractor needs to be stopped before gear shifting to avoid teeth damage.

- **Advantages:**
    a. All the gears are in constant mesh, wear and tear of gears and any possible Damage of gears do not occur in engaging and disengaging gears.
    b. Helical gears are used to reduce shifting noise and shifting efforts.

- **Limitations:**
    a) Tractor needs to be stopped before gear shifting to avoid teeth damage.

2.3.3 Synchromesh gear box

1. The synchromesh transmission is basically a constant mesh transmission with an extra device called a **synchronizer** to equalize the speed of the mating parts before they engage.
2. This system is very common on automobiles & is very rarely used on tractor transmission.
3. This type of transmission is suitable for changing the speeds when tractor is moving.
4. The synchronizing device synchronizes the speed of two gears and shafts before changing the appropriate gear.
5. Small friction clutches usually cone type are used to synchronize the speed of collars and gears.

Advantages :

1. Gear shift can be made without damaging, even when tractor is moving.
2. Popular in tractors used for highway transport purpose.

Disadvantages :

1. It has low power transmission efficiency than sliding mesh gear box.
2. This system is more costly.

2.4 Trouble shootings

2.4.1 Gears hard to shift

Possible cause		Remedy
• Improper clutch adjustment .	---	Adjust.
• Shifting lock spring too strong.	---	Adjust.
• Sliding gear teeth damaged.	---	Replace.
• Transmission shaft splines bent or distorted.	---	Replace.
• Gear shifter lock spring too weak.	---	Align, replace if damaged.

2.4.2 Gears slip out of mesh

Possible cause		Remedy
• Shifter lock spring too weak.	---	Install new spring.
• Gear teeth excessively worn out.	---	Replace worn out parts.
• Gears do not engage fully.	---	Check and adjust the travel of shift rails & forks.
• Mounting shaft misaligned or bent.	---	Check and adjust the travel of shift rails & forks.

2.4.3 Noise in transmission

1) When transmission is neutral

Possible cause		Remedy
• Lack of lubrication.	---	Refil. Top up to the mark.
• Bearing dry, worn or broken.	---	Replace.
• Excessive end play of counter shaft.	---	Replace
• Excessive end play of counter shaft.	---	Adjust or replace worn out parts.
• Badly worn out counter shaft.	---	Replace

2) When transmission engaged

Possible cause		Remedy
• Lack of lubrication.	---	Refil. Top up to the mark.
• Bearing dry, worn or broken.	---	Replace.
• Excessive end play of counter shaft.	---	Replace.
• Excessive end play of counter shaft.	---	Adjust or replace worn out parts.
• Badly worn out counter shaft.	---	Replace.
• Main shaft worn or broken.	---	Replace.
• Worn out or damaged gears on main shaft.	---	Replace.

2.4.4 Lubricant leaks

Possible cause		Remedy
• Too high oil level.	---	Drain to proper level.
• Damaged or improperly installed gaskets.	---	Install new gasket.
• Oil seals damaged or improperly installed.	---	Install new gasket.
• Loose cover bolts.	---	tighten bolts.
• Transmission case cracked.	---	repair replace.
• Oil foaming.	—	Replace with good quality oil

NUMERICALS

2.1 A tractor has 1.5 metre rear wheel diameter. If the final drive gear ratio is 5:1 and differential gear ratio is 3:1 find traveling speed of the tractor when the speed of the engine is 1250 rev./min and gear box reduction is 2:1.

Answer:

Data: Rear wheel diameter = 1.5 metre, final drive gear ratio = 5:1
differential gear ratio is 3:1 gear box reduction is 2:1

speed of the engine = 1250 rev./min

Rear wheel speed = engine speed x gear box reduction x differential gear ratio x final drive gear ratio

= 1250 x 1/2 x 1/3 x 1/5

= <u>41.66 rpm</u>

$$\text{Speed of travel} = \frac{\Pi \times D \times N \times 60}{1000} = \frac{3.142 \times 1.5 \times 41.66 \times 60}{1000} = \mathbf{\underline{11.77\ Km/hr}}$$

2.2 A 25 hp tractor is running at 1000 rev/min, total reduction of speed is 10:1. Find the tractive force at each driving wheel, if the diameter of the driving wheels is 1.32 metres. (Sem. End. Exam. 2011-12)

Answer:

Data: Drive wheel diameter = 1.32 metre, Speed of the engine = 1000 rev./min

Differential gear ratio is 3:1 Total speed reduction = 10:1

$$\text{Speed of drive wheels (N)} = \frac{\text{Speed of the engine}}{\text{Total speed reduction}} = \frac{1000}{10} = 100 \text{ rpm}$$

$$\text{Power, (Hp)} = \frac{2 \times \text{Torque (kg-m)} \times \text{N (rpm)}}{4500}$$

$$\therefore \text{Torque (kg-m)} = \frac{\text{Power} \times 4500}{2 \times \times \text{rpm}}$$

$$= \frac{25 \times 4500}{2 \times 3.142 \times 100}$$

∴ Torque (kg-m = **179.02 Kg-m**

Now,

$$\text{Tractive force at each driving wheel} = \frac{\text{Torque}}{\text{radius of drive whee}}$$

$$\therefore \text{Tractive force at each driving wheel} = \frac{179.02 \text{ kg-m}}{(1.32/2)} = \mathbf{271.25\ kg}$$

2.3 Find the speed ratio between crankshaft speed and rear axle speed for a tractor with 115 cm rear wheel diameter running at a speed 4 km /hr and engine speed of 2200 rev/min.

Answer:

Data: Rear wheel diameter (D) = 115 cm i. e. = 1.15 m, Speed of the engine = 2200 rpm , Travel speed = 4 km /hr

We have,

$$\text{Travel speed} = 4 \text{ km /hr} = \frac{4 \times 1000}{60} = 66.66 \text{ m/min}$$

Now, Linear speed of tractor = Travel speed = 66.66 m/min

∴ $66.66 \text{ m/min} = \Pi \times D \times N$

$= 3.142 \times 1.15 \times N$

∴ Rear axle speed, $N = 66.66 / (3.142 \times 1.15)$

$= 18.44$ rpm

$$\text{Required speed ratio} = \frac{\text{Speed of the engine (Crank shaft)}}{\text{Rear axle speed}}$$

$$\text{Required speed ratio} = \frac{2200}{18.44} = \frac{119.3}{1}$$

∴ The speed ratio between crankshaft speed and rear axle speed = 119.3 : 1

2.4 Two spur gears transmitting motion on parallel shafts has driven to driver ratio of 8. The driven shaft has to rotate at 1400 rpm and the gear on it has 24 teeth. How many teeth must the driver have, and with what speed it must rotate? What is the spacing between the shafts if the gear wheel has a module of 12.7 mm.

Answer:

Data: Driven to driver ratio = 8, Speed of driven, N_n = 1400 rev./min,

No. of teeth on driven, T_n = 24 Module = 12.7 mm

Consider,

N_n, D_n & T_n is Speed, Diameter and No. of teeth on driven, and

N_r, D_r & T_r is Speed, Diameter and No. of teeth on driver.

We have, $\frac{T_r}{} = \frac{N_n}{} = 8$ (given)

$\therefore \frac{T_n}{} = \frac{N_r}{N_n}$

$\therefore T_r = \frac{}{N_r} T_n$

$T_r = 8 * 24 = 192$ teeth

$\therefore$ **No. of teeth on driver = 192**

Now,

Speed of driven, $N_n = \frac{T_n * N_n}{N_r} = \frac{24 * 1400}{192} =$ **175 rpm** (given)

And, Diameter of driver, $D_r = T_r * \text{module} = 192 * 12.7 = 2438.4$ mm

Diameter of driven, $D_n = T_n * \text{module} = 24 * 12.7 = 304.8$ mm

$\therefore$ Spacing between the shafts $= \frac{D_r + D_n}{2} = \frac{2438.4 + 304.8}{2} =$ **1371.6 mm**

2.5 A sliding mesh type gear box with forward speds only is to be designed. The gear box should have the following gear ratios available approximately: 1.0, 1.5, 2.5 and 3.9. The centre distance between the lay shaft and main shaft is 78 mm and the smaller gear is to have at least 16 teeth with dimetral pitch of 3.25 mm. Calculate the number of teeth of the various gear and the exact gear ratios thus available.

Answer:

Consider, following figure, Where, T = No. of teeth, N= Speed and G = Gear ratio

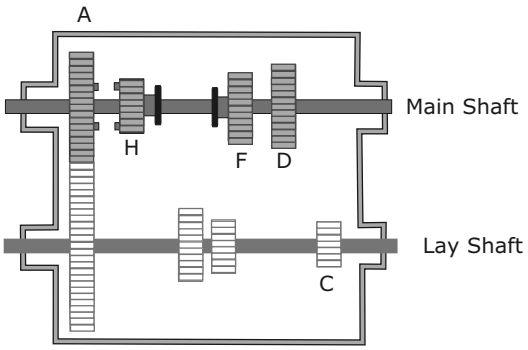


Figure sliding mesh gear box

$$T_A + T_B = T_C + T_D = T_E + T_F = T_G + T_H = (78 \times 2)/3.25 = 48 \quad \text{---- (1)}$$

First gear

$$\text{Gear ratio, } G_1 = \frac{N_A}{N_D} = \frac{T_D}{T_C} \times \frac{T_B}{T_A}$$

$$3.9 = \frac{T_D}{T_C} \times \frac{T_B}{T_A} \quad \text{----(2)}$$

Second gear:

$$\text{Gear ratio, } G_2 = \frac{N_A}{N_F} = \frac{T_F}{T_E} \times \frac{T_B}{T_A}$$

$$2.5 = \frac{T_F}{T_E} \times \frac{T_B}{T_A} \qquad \text{----(3)}$$

Third gear:

$$\text{Gear ratio, } G_2 = \frac{N_A}{N_H} = \frac{T_H}{T_G} \times \frac{T_B}{T_A}$$

$$1.5 = \frac{T_H}{T_G} \times \frac{T_B}{T_A} \qquad \text{--- (4)}$$

Now, Smallest gear is to have 16 teeth Hence, let, $T_A = 16$

Then, from equation (1),

$$T_B = 48 - T_A = 48\text{-}16 = \mathbf{32}$$

From equation (2),

$$3.9 = \frac{T_D}{T_C} \times \frac{32}{16}$$

$$\frac{T_D}{T_C} = \frac{3.9 * 16}{32} = \mathbf{1.95}$$

Substituting in equation (1),

$$T_C + 1.95\,T_C = 48$$

$$T_C = 16.2 \text{ say } \mathbf{16}$$

$$T_D = 48 - 16 = \mathbf{32}$$

From equation (3),

$$2.5 = \frac{T_F}{T_E} \times \frac{T_B}{T_A}$$

$$\frac{T_F}{T_E} = \frac{2.5 * 16}{32} = \mathbf{1.25} \quad \text{i.e.} \quad T_F = 1.25\,T_E$$

Substituting in equation (1),

$$T_E + 1.25\,T_E = 48$$

$$\mathbf{T_E} = 21.3 \text{ say } \mathbf{21}$$

$$\mathbf{T_F} = 48 - 21 = \mathbf{27}$$

From equation (4),

$$1.5 = \frac{T_H}{T_G} \times \frac{32}{16}$$

$$\frac{T_H}{T_G} = \frac{1.5 * 16}{32} = \mathbf{0.75} \quad \text{i.e.} \quad T_H = 0.75\,T_G$$

Substituting in equation (1),

$$T_G + 0.75\,T_G = 48$$

$$\mathbf{T_G} = 27.4 \text{ say } \mathbf{27}$$

$$\mathbf{T_H} = 48 - 27 = \mathbf{21}$$

Hence, Exact gear ratios are:

Gear ratio, $\mathbf{G_1} = \frac{32}{16} \times \frac{32}{16} = \mathbf{4.00}$

Gear ratio, $\mathbf{G_2} = \frac{27}{21} \times \frac{32}{16} = \mathbf{2.57}$

Gear ratio, $\mathbf{G_3} = \frac{21}{27} \times \frac{32}{16} = \mathbf{1.55}$

QUESTIONS

Q. 1 Why gear box is needed in tractors?

Q. 2 Explain Principle of Gearing. (Sem. End. Exam. 2009-10, 2010-11)

Q. 3 Enlist the different types of gear box available on tractors.

Q. 4 Explain sliding mesh gear box. (Sem. End. Exam. 2011-12)

Q. 5 Explain Constant Mesh Gear Box.

Q. 6 Explain synchromesh gear box.

OBJECTIVE QUESTIONS

A) Fill in the Blanks:

1. Gear housing is made up of ----
2. The gearbox is incorporated in-between the engine & rear wheels which is a solution for the ---- & ----
3. A combination of gear wheels by means of which motion is transmitted from one shaft to another shaft is called a ----
4. In sliding mesh gear box the upper shaft is known as the ---- & the lower one is known as ----
5. The gears on lay shaft are ----
6. The gears on the ---- shaft slide to mesh.
7. Shifting of gears from one position to another on spline shaft is achieved by ---- and ---.
8. The ---- has parallel shafts one over the other with gears in constant mesh.
9. The synchromesh gear box is basically a ----.
10. Synchromesh gear box is with an extra device called a ----
11. Torque convertor is called as ----
12. The grade of oil used in the tractor gear box is ----

B) Multiple choice questions:

1. If the no. Of teeth on driven gear is doubled, the speed becomes ---- of the driving gear.
   a) Half b) Double c) Equal d) No effect
2. ---- type of transmission is suitable for changing the speeds when tractor is moving.
   a) Sliding mesh b) Constant mesh c) Synchromesh d) both (a) and (b)
3. ---- type gears are used for high velocity.
   a) Spur b) Helical c) both (a) and (b) d) None of these
4. The advantage of using helical gears rather than spur gears in a transmission are ----
   a) High strength & low cost c)) High strength & less end thrust
   B) High strength & low Noise d) Low nose & economy

ANSWERS

A) Fill in the Blanks:

1. Cast iron.
2. Variable torque & speed.
3. gear train.
4. main shaft, …. counter shaft or lay shaft.
5. Fixed
6. Main
7. gear shifting rails and forks.
8. constant mesh gear box.
9. constant mesh gear box.
10. Synchronizer
11. Hydrokinetic transmission.
12. SAE-90

B) Multiple choice questions:

1. Half
2. Synchromesh
3. Helical
4. High strength & low Noise

Chapter
3

DIFFERENTIAL AND FINAL DRIVE

Contents:

In rear-wheel drive cars, the differential converts rotational motion of the transmission shaft which lies parallel to the car's motion to rotational motion of the half-shafts, which lie perpendicular to the car's motion.

When a car turns a corner, one wheel is on the "inside" of a turning arc, and the other wheel is on the "outside." Consequently, the outside wheel has to turn faster than the inside one in order to cover the greater distance in the same amount of time. Thus, because the two wheels are not driven with the same speed, a differential is necessary.

3.1 Necessity & function of differential unit in a tractor

- The following example will help us to understand the function of differential in any tractor
- Consider, a group of soldiers marching in three.

- **At turning,** to remain all three soldiers in a row to be in one line the soldier on the outer side of turn will have to be faster, while the soldier on inner side will have to be slower.
- Similarly, if the axle is the single unit & wheels are free on axle moving on bearings, (viz. bullock-cart axle, tractor or automobile front axle), the wheels will turn at different speeds to compensate for difference in travel.
- Hence, a device is necessary which can make the wheels move at different speeds on turns, whereas the speed of both wheels should remain equal when vehicle is following a straight road.
- To accomplish this purpose a system of planetary gears called the differential is provided.

- **Thus the differential has two functions,**
  i) On straight travel, it allows both rear wheels of tractor to get equal power & speed.
  ii) On turns, it allows inner side drive wheel to move slower than outer wheel.

3.2 Principle of operation of differential unit

- **Case- I (Straight road)**

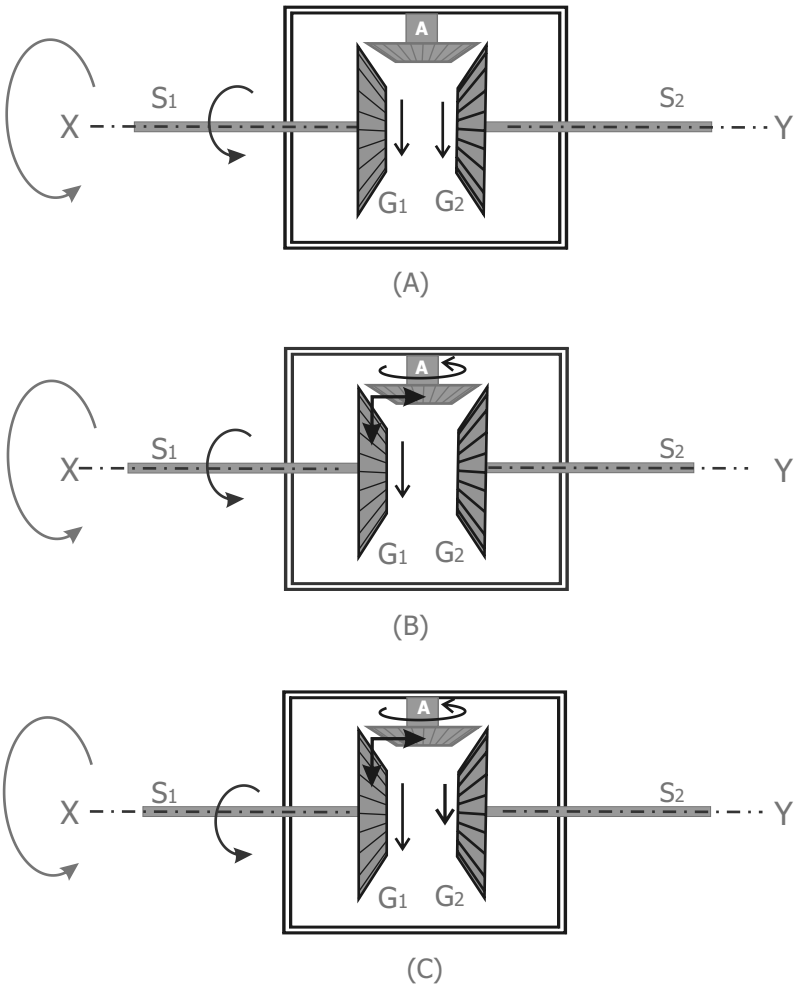
  Casing C = Rotating

  Shafts S_1 & S_2 or gears G_1 & G_2 = Rotating

  Pinion, P = Not revolving on its own shaft (shaft 'A').

- **In this case when casing C is rotated about its axis XY,** pinion P does not revolve on it's axis, but acts as a key between gears G_1 & G_2 making them rotate on their own axes.

- Thus the gears on the shaft S_1 & S_2 rotate with same magnitude & direction as that of casing C is rotating.



G_1 & G_2 = Two large bevel gears mounted on two shafts S_1 & S_2 resp.

P = It is the pinion driven by gear G_1 & G_2. It is mounted on shaft 'A'.

C = Casing in which shaft 'A' is fixed.

Figure 3.1 Principle of operation of differential unit

- **Case- II (Straight road)**

Casing, C = Rotating

Shaft S_2 or gear G_2 = Stationary

- **In this case, consider that shaft S_2 is being held stationary so that its gear G_2 cannot rotate while casing C is still rotating in same direction**.

As gear G_2 is stationary, pinion P will roll over gear G_2 , while revolving around its own axis. On the other hand, bevel gear G_1 will move two times faster than the speed in first case. This is because an additional speed has added due to the relative motion between pinion P & gear G_1.

- **Case -III (On turn)**

Casing, C = Rotating

Shaft S_2 or gear G_2 = Neither stationary nor rotating

In this case, suppose shaft S_2 is neither held stationary nor it is being relived, but is allowed to slip slightly so that it moves in the same direction in which casing is rotating.

Now pinion 'P' will roll over gear G_2 at a slower speed than that of case second. Hence shaft S_1 will rotate accordingly slower than second case because of speed of casing C plus relative speed between pinion P & bevel gear G_1.

However, the algebraic sum of the speeds of shafts S_1 & S_2 will remain the same as in cases 1 & 2.

On straight roads, the speed of both half axles remain same (case-I) & on. **Turns,** the inner wheel is subjected to more resistance & hence it becomes slower while outer moves faster (case-III).

3.3 Operational details of differential unit

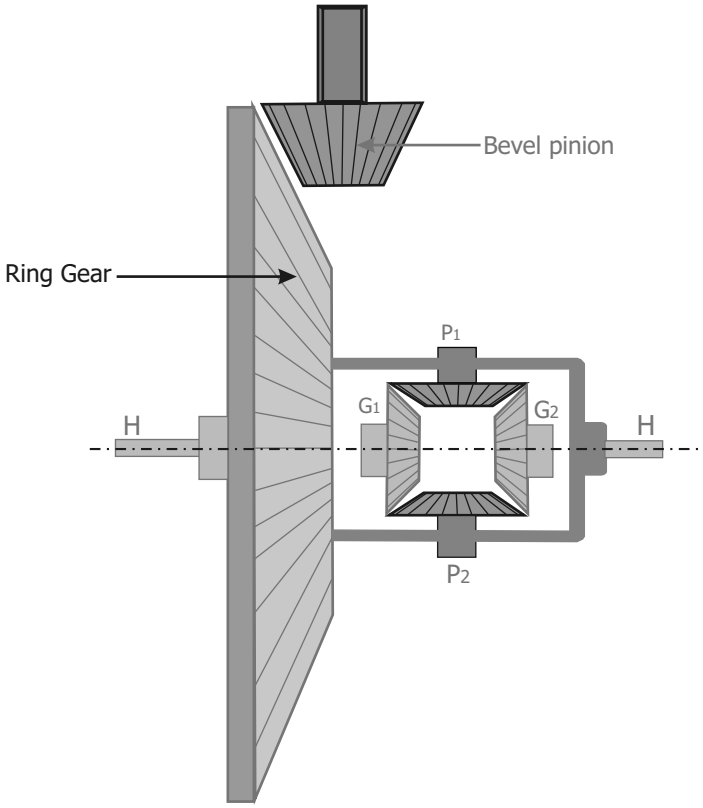


Figure 3.2 Operational details of differential unit

Construction:

- The output shaft coming from gear box carries a bevel gear and its end drives the crown wheel (ring gear).
- A metallic case known as the differential cage is mounted on crown wheel and moves together as single unit.
- Two bevel differential pinions P_1 & P_2 are mounted on axle A present inside casing such that they are carried by crown wheel and they are free to rotate on their own axis also.
- Side gears G_1 & G_2 are mounted on splined end of half axles, which goes to the tractor rear wheels.

Working:

- **On straight roads,** the differential cage moves along with crown wheel carrying differential pinions & side gears. There is no relative motion among pinions, causing both half axles and side gears to rotate at equal speed.
- **When tractor is on turn,** unequal resistance will come across both wheels. Hence, the speed of wheel subjected to more resistance will be reduced & accordingly the other wheel will accelerate in motion and tractor get turned.
- Sometimes the differential pinions are four in number.

3.4 Transmission efficiency of differential

Transmission efficiency of differential of tractor is given by:

$$\eta = \frac{P_{oa}}{P_{ip}} = \frac{\text{Power out put through both axles, kW}}{\text{Power input by bevel pinion, kW}}$$

Also,

If,

T_{oal} = Torque output from left axle, N-m

T_{oar} = Torque output from right axle, N-m

N_{al} = RPM of left axle,

N_{ar} = RPM of right axle,

T_{ip} = Torque input by bevel pinion, N-m

N_{ap} = RPM of pinion.

Then,

$$\eta = \frac{T_{oal} * N_{al} + T_{oar} * N_{ar}}{T_{ip} * N_{ip}}$$

3.5 Differential Lock

- As soon as one wheel offers less resistance it turns faster causing a loss of traction.
- If one wheel gets in the mud or in loose soil, the wheel on solid ground will not turn while the other will spin around due to differential action.
- To overcome this problem, every tractor is provided with a locking system known as differential lock.
- The purpose of lock is to join both half axles so that even if one wheel is under less resistance, tractor comes out from mud or area offering less resistance as both wheels move with the same speed & apply equal traction.

3.6 Final drive

- "Final drive is a gear reduction unit in the power train present between differential and drive wheels."
- It helps in minimizing the number of gear & shaft in the gear box **to achieve higher torque with less speed on driving wheels**.
- It provide about 3:1 to 5:1 reduction.
- It is mounted near the rear drive wheel of the tractor.
- Final drive transmits the power finally to the rear axle and wheels.
- Tractor drive 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 known as bull gear.
- Bull gear is mounted on the shaft carrying rear wheel.
- The device for final speed reduction, is suitable for tractor rear wheels, is known as Final Drive Mechanism.
- Some of the manufactures do not provide for a final drive & the speed and torque are covered under the transmission itself.

- Types of final drive are:
  1. A set of pinions & bull gears in a separate portal housing.
  2. A set of pinions & bull gears in the differential housing.
  3. Planetary gears.

3.6.1 Planetary final drive.

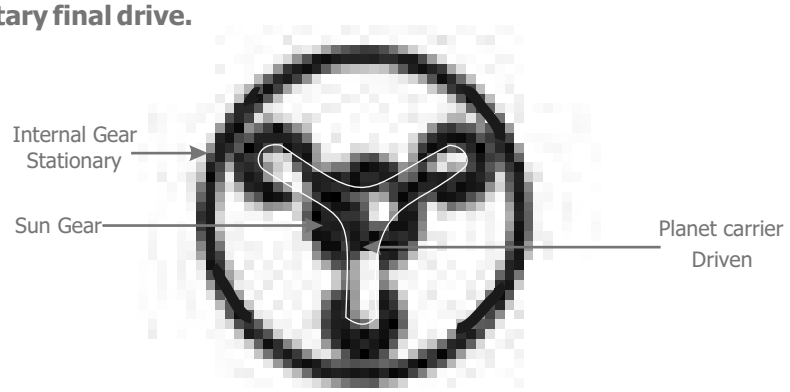


Figure 3.3 Planetary final drive

- Since torque loads are spread almost equally over the several gears, this system is smaller & compact and is more durable under heavy loads.
- It is driven by differential through final drive shaft & sun gear.
- The sun gear which is an integral part of final drive rotates in the direction indicated while the planetary pinions rotate & progress around the final drive gear. .
- The rear axle is attached to planet pinion carrier.

QUESTIONS

Q. 1 Explain the necessity & function of differential unit in a tractor.

Q. 2 Explain principle of operation of differential unit with neat diagram. (Sem. End. Exam. 2008-09, 2009-10 and 2010-11)

Q. 3 Explain operational details of differential unit with neat diagram. (Sem. End. Exam. 2011-12)

Q. 4 Write a note on differential lock. (Sem. End. Exam. 2008-09 , 2009-10 and 2010-11)

Q. 5 What is final drive? Explain in short.

Q. 6 Explain planetary final drive in short. (Sem. End. Exam. 2008-09)

OBJECTIVE QUESTIONS

1. Output shafts at the differential are known as ----
2. The gear train used in a differential is an ---- type gear train
3. ---- type final drive system is smaller and compact.
4. ---- is the biggest size gear in the differential unit.
5. A metallic case mounted on crown wheel of differential unit is known as ----
6. Application of ----causes both rear wheels to move with same speed and apply equal traction.
7. ---- helps in minimizing number of gears and shafts in gear box to achieve higher torque with less speed at driving wheels.
8. Final drive is a gear reduction unit in the power train present between ---- & ----
9. Final drive provide about ---- reduction in speed.
10. When one wheel of tractor is braked the speed of other wheel wil be ----
11. Ring gear is present in ----- unit of tractor.
12. Bull gear is present in ----- unit of tractor.

ANSWERS

1. half axles.
2. Epicyclic
3. Planetary
4. Ring Gear
5. Differential cage.
6. differential lock
7. Final drive
8. Differential and drive wheels.
9. 3:1 to 5:1
10. Doubled
11. Differential
12. Final drive

Chapter
4

BRAKES

Contents:

The safety of an operator in any vehicle depends upon the speed control as and when required. To accomplish this need the brakes are essential on every vehicle. "The function of brake system in a tractor is to bring it to a stop or slow down it motion".

In tractors brake is operated by two separate pedals. Each brake pedal can be operated independently to assist turning during the field work or the pedals can be locked together with a lock during road transport.

4.1 Classification of brakes

The brake system of vehicles has a variety of types, the present tractors available in the country are of following types :

A) Mechanical brake

i) Internal expanding shoe brake.
ii) External contracting shoe brake.
iii) Disc brake.

B) Hydraulic brake

4.2 Internal expanding shoe brake.

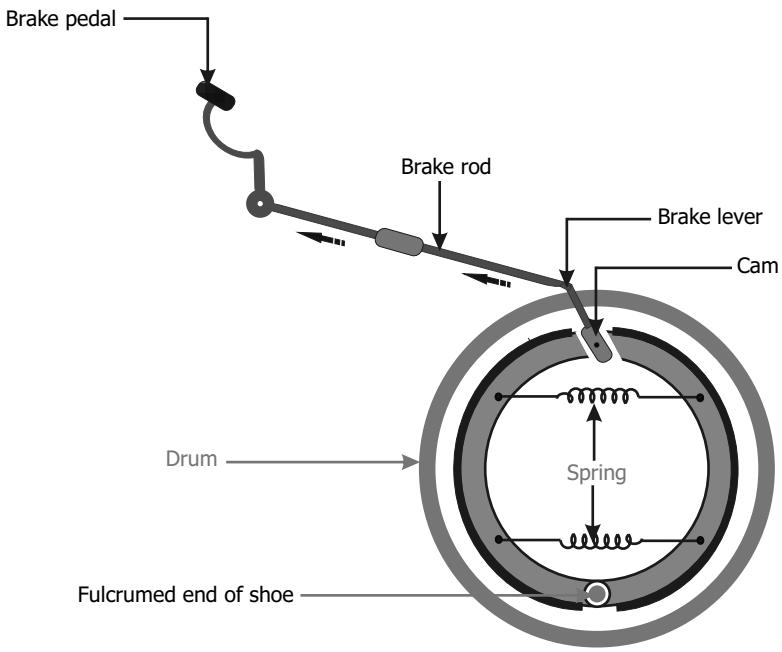


Figure 3.1 Internal expanding shoe brake

- The two brake shoes made of frictional material fit on the inside of drum which is mounted on the rear axle. The brake shoes are held away from drum by means of springs (fig.3.1).
- One end of each shoe is fulcrumed, whereas the other is free to move by action of a cam.
- The force applied on the foot pedal is transferred to the cam through linkage to cause the movement of shoes.

- **As brake pedal is depressed** linkage causes the movement of cam and the cam presses the brake shoes outwards to contact and to rub against rotating drum. Due to friction between drum and brake shoes the speed of rotating drum is reduced.
- **As the pedal is released** the springs bring the brake shoes back to the original position removing contact between rotating drum and brake shoes and drum rotates freely.

4.3 Brake pedal free play

- By constant use the brake lining wears out gradually, which is noticed by a gradual increases in pedal travel before effective braking is obtained, known as excess pedal free play.
- "The travel of brake pedal before effective braking is obtained is known as brake pedal free play."
- Therefore, at regular intervals the pedal free play should be checked & adjusted.

4.4 External contracting shoe brakes

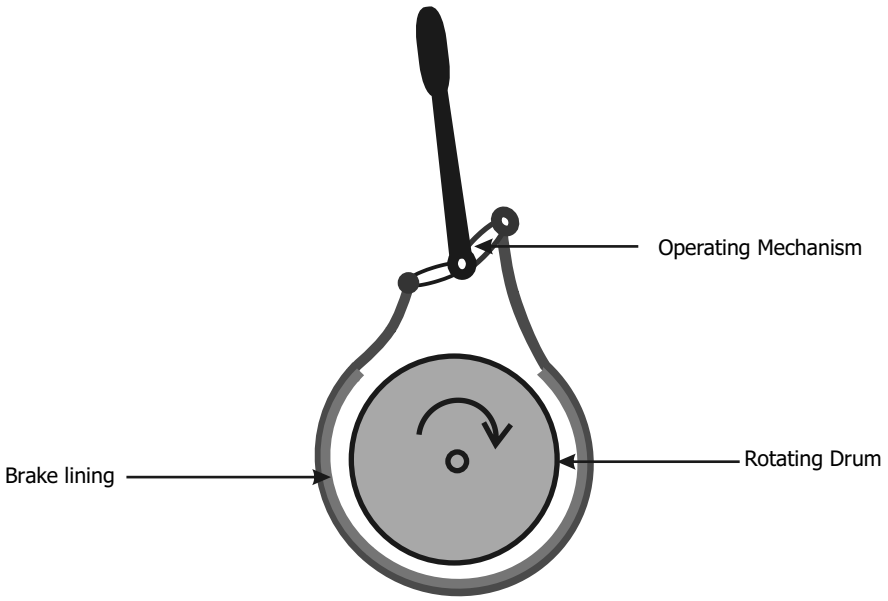


Figure 3.2 External contracting shoe brake.

- The drum mounted on the drive axle/drum is directly surrounded by brake band.
- When pedal is depressed, the band tightens to drum and reduces the speed.
- This type of brake system is normally available on crawler tractors and as a parking brake.
- It is simplest in construction & easy in operation.
- Adjustment for the brake lining is done by adjusting nuts provided thereon.

4.5 Disc brake

- This type of brake is self energizing.
- The natural movement of various parts is used to increase the braking action once it is started by foot pedal.
- Two actuating discs have hole drilled in each disc in which steel balls are placed.
- **When pedal depressed** the link moves the two discs in opposite directions which brings the balls to shallow part of hole drilled in the disc.
- As a result, the two disc are expanded & braking discs are pressed in between the discs & the stationary housing.
- The braking discs are directly mounted on the differential shaft, which ultimately transfers the braking effort to the differential shaft.

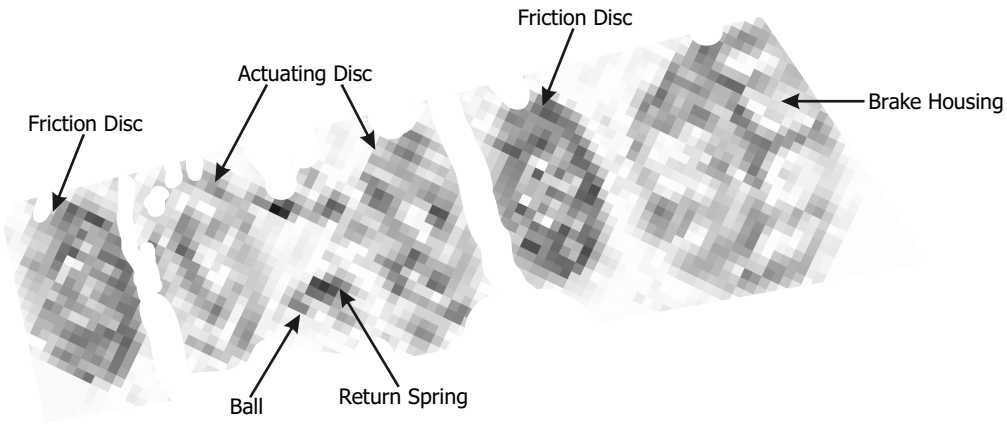


Figure 3.3 Exploded view of disc brake

4.6 Principal of operation of hydraulic brake

- The hydraulic brake works on principle of hydraulics known as **pascal's law** which is stated as, "The pressure applied to fluid in a closed container is transmitted with equal intensity throughout the liquid & at right angles to the surface of the container."

- The force applied to a pedal is multiplied & transmitted to all the wheels in equal magnitude is the advantage of the hydraulic system, whereas in case of mechanical brakes the efficiency of an individual links is affected by the adjustment of individual links.

4.7 Working of hydraulic brake system

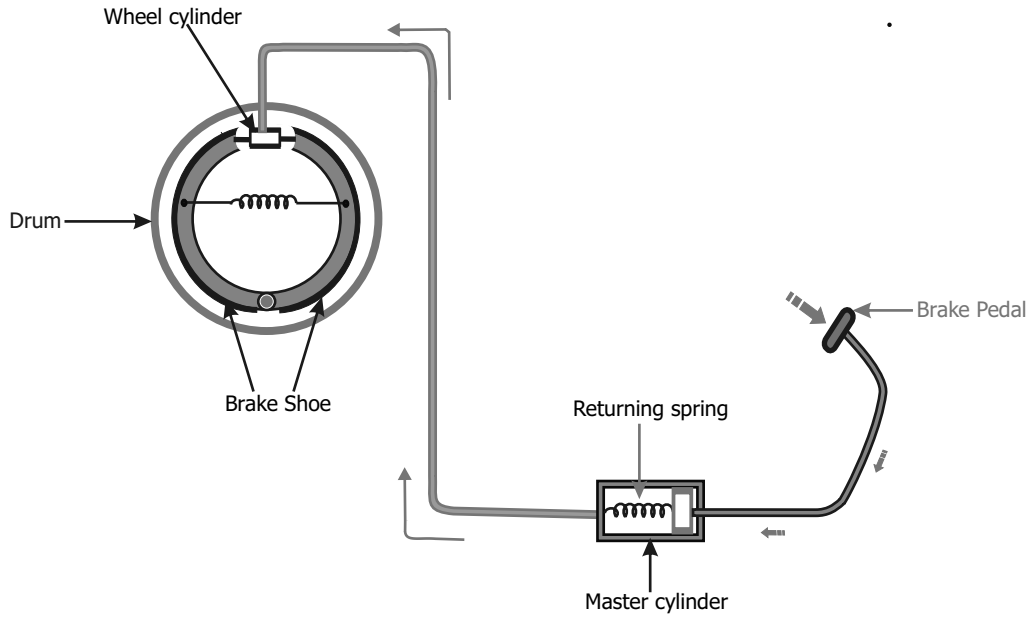


Figure 3.4 Working of hydraulic brake system

- The hydraulic brake works on the principal of pascal's law.
- It has two main components master cylinder and wheel cylinder (Fig.3.4).
- A mixture of glycerin & alcohol, or castor oil & denatured alcohol is filled in the master cylinder. This mixture is known as brake fluid.
- **When the pedal is depressed,** the piston of master cylinder is forced into the cylinder & entire system turns to a pressure system immediately, the pistons of wheel cylinder slide outward. This outward movement of pistons moves the brake shoes outwards to contact the rotating drum to reduce its speed.
- **When pedal is released,** the return spring of master cylinder moves the piston back to its original position causing a sudden pressure drop in the line. The returning springs of brake shoes bring them back to their original position & accordingly the pistons of wheel cylinder will also return and the drum rotates freely without friction.
- In addition to this brake linkage & other mechanisms of mechanical brake have been replaced by hydraulic piping, hence the system is simplified.

QUESTIONS

Q. 1 What is brake? How brakes are classified? (Sem. End. Exam. 2008-09 and 2009-10)

Q. 2 Explain internal expanding shoe brakes with neat diagram. (Sem. End. Exam. 2009-10)

Q. 3 What is excessive brake pedal free play?

Q. 4 Explain external contracting shoe brakes with neat diagram.

Q. 5 Explain disc brakes. (Sem. End. Exam. 201-12)

Q. 6 Explain principle of operation and working of hydraulic brake with neat diagram. (Sem. End. Exam. 2008-09 and 2010-11)

OBJECTIVE QUESTIONS

A) Fill in the Blanks:

1. The principle of operation of shoe brake is based on principle of ----
2. The hydraulic brake works on principle of ----
3. Brake fluid is usually a mixture of ---- and ----
4. The hydraulic brake has two cylinders viz. ---- and ----
5. In External Contracting Shoe Brakes drum drive wheel is directly surrounded by ----
6. The distance travelled by the brake pedal before effective braking is obtained is called as ----
7. Free play of brake pedal of tractor is about ---- mm.
8. The brake test in tractor testing is performed at a maximum sped of ----
9. The brakes are considered cold when their temperature is ----
10. The brakes are considered hot when their temperature is ----
11. A free play of ---- mm is required to avoid brake drag.

B) Multiple choice questions:

1. Brake fluid is filled in the ----

   a) Master cylinder b) Wheel cylinder c) Drum d) All (a), (b), & (c)

2. Generally parking brakes are ---- type brakes.

   a) Internal Expanding shoe b) External contracting shoe

   c) Disc d) Hydraulic