Working principle of speed reduction and torque transmission

GEAR SYSTEM

- 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 become essential to reduce the engine speed and increase the torque available at the rear wheels of the tractor because engine power is constant.
- Power(kW) = $\frac{2 \times \pi \times N \times T}{60 \times 10^3}$
- Where,
- T= Torque in Nm
- N=Speed in rev/min(rpm)

- The requirement of a transmission/Gear 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.

 All these purposes are fulfilled using series of gears. There are various types of gears that are used for tractor and automotive applications. The Fig. shows the different types of gears used on tractors



Various types of gearing are used on a motor vehicle. The gearboxes employ one or more of the following:

- 1- Spur, teeth parallel to axis, used on sliding mesh.
- 2- Helical, teeth inclined to axis to form helix.
- 3- Double helical, two sets of opposing helical teeth.
- 4- Epicyclical or planetary, spur or helical gears rotating about centers which are not stationary.

Principle behind Gear Box

- Consider following three cases in which there are a pair of gears in each case. The gear A is the driver and gear B is the driven.
- In case I, the gear A (driver) is larger than gear B (driven), this case there is an increase in rpm of the driven as compared to the driver based on the following relation. ($n_A < n_B$)

$\Rightarrow n_b = \frac{\varphi_A}{\varphi_B} \cdot n_A$ Where $Ø_A = \text{diameter of gear } A$ $Ø_{\rm B}$ = diameter of gear B $n_A = rpm of gear A$ $n_{B} = rpm of gear B$

 $\emptyset_A n_A = \emptyset_B n_B$



Case I

Case II

Case III

- In case II, \emptyset_A is equal to \emptyset_B meaning that there is no change in the output speed as compared to the input speed. $n_A = n_B$
- In case III, $Ø_A$ is smaller than $Ø_B$, leading to reduction of output rpm as compared to the input rpm. $n_A > n_B$

Study of Torque output



- When the driver gear A drives the gear B with a torque, the torque exerted by gear A is given by $T_A = F \times r_A$
- Where r_A is radius of gear A.
- F is the force that the gear A exerts.
- Going back to the earlier figures the torque generated in gear B will be given by

$$T_B = F \times r_B$$

- In case of Case I,
- $T_A > T_B$ because $r_A > r_B$
- In case II,
- $T_A = T_B (r_A = r_B)$
- In case III,
- $T_A < T_B$ because $(r_A < r_B)$
- Therefore from the analysis of the three cases for both torque and speed, it can be stated that in a combination of gears where speed is increasing, torque reduces and vice-versa.

Types and construction details of gear boxes

- Since the torque requirement for doing the various agricultural operations is continuously varying, there is a constant need for changing the set of gears involved in transmission of the engine power to the wheels.
- There are a number of ways in which gears can be combined to alter the torque being supplied to the tractor wheels.
- A series of gears are often combined together in a Gear Box in an orderly manner.

Gear boxes used for transmission systems are classified into:

- Sliding Mesh Gear Box
- Constant Mesh Gear Box
- 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)

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 slide over the main shaft to mesh with corresponding gear on the counter shaft.
- 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.



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







Cross-sectional view of a Sliding Mesh Gear Box

 This shows the various components of a sliding mesh gear box. The gears 4, 5 and 6 on the main shaft can be slide 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.
- Usually the gears are helical in shape.



Synchromesh Gear Box

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

