Necessity Of Gear Box In An Automobile

• The gear box is necessary in the transmission system to maintain engine speed at the most economical value under all conditions of vehicle movement.

• An ideal gear box would provide an infinite range of gear ratios, so that the engine speed should be kept at or near that the maximum power is developed whatever the speed of the vehicle.
Function Of A Gear Box

• Torque ratio between the engine and wheels to be varied for rapid acceleration and for climbing gradients.
• It provides means of reversal of vehicle motion.
• Transmission can be disconnected from engine by neutral position of gear box.
Selective Type Gear Box

- It is the transmission in which any speed may be selected from the neutral position.
- In this type of transmission neutral position has to be obtained before selecting any forward or reverse gear. Some selective type gear boxes are,
  1. Constant mesh gear box with positive dog clutch.
  2. Constant mesh gear box with synchromesh device.
  3. Sliding mesh gear box
Sliding mesh gear box

It is the simplest and oldest type of gear box.

1. The clutch gear is rigidly fixed to the clutch shaft.

2. The clutch gear always remains connected to the drive gear of countershaft.

3. The other lay shaft gears are also rigidly fixed with it.

4. Two gears are mounted on the main shaft and can be sliding by shifter yoke when shifter is operated.

5. One gear is second & top speed gear and the other is the first and reverse speed gears. All gears used are spur gears.

6. A reverse idler gear is mounted on another shaft and always remains connected to reverse gear of counter shaft
Sliding mesh gear box

[Diagram of a sliding mesh gear box with labeled parts: A, B, C, D, E, F, G, CLUTCH SHAFT, CLUTCH GEAR, FIRST & REVERSE GEAR, SECOND & HIGH SPEED GEAR, MAIN SHAFT, LAY SHAFT (COUNTER SHAFT).]
FIRST GEAR

• By operating gearshift lever, the larger gear on main shaft is made to slide and mesh with first gear of countershaft.
• The main shaft turns in the same direction as clutch shaft in the ratio of 3:1.

SECOND GEAR

• By operating gear shaft lever, the smaller gear on the main shaft is made to slide and mesh with second gear of countershaft.
• A gear reduction of approximately 2:1 is obtained.

TOP GEAR

• By operating gearshift lever, the combined second speed gear and top speed gear is forced axially against clutch shaft gear.
• External teeth on clutch gear mesh with internal teeth on top gear and the gear ratio is 1:1.
REVERSE GEAR

• By operating gearshift lever, the larger gear of main shaft is meshed with reverse idler gear.

• The reverse idler gear is always on the mesh with counter shaft reverse gear. Interposing the idler gear, between reverse and main shaft gear, the main shaft turns in a direction opposite to clutch shaft.

NEUTRAL GEAR

• When engine is running and the clutch is engaged, clutch shaft gear drives the drive gear of the lay shaft and thus lay shaft also rotates.

• But the main shaft remains stationary as no gears in main shaft are engaged with lay shaft gears.
CONSTANT MESH GEARBOX
Explanation about the constant mesh gearbox

- In this type of gearbox, all the gears of the main shaft are in constant mesh with corresponding gears of the countershaft.
- The gears on the main shaft which are bushed are free to rotate.
- The dog clutches are provided on main shaft.
- The gears on the lay shaft are, however, fixed.
- When the left Dog clutch is slide to the left by means of the selector mechanism, its teeth are engaged with those on the clutch gear and we get the direct gear
Contd....

• The same dog clutch, however, when slide to right makes contact with the second gear and second gear is obtained.

• Similarly movement of the right dog clutch to the left results in low gear and towards right in reverse gear. Usually the helical gears are used in constant mesh gearbox for smooth and noiseless operation
SYNCHROMESH GEARBOX
During engaged the synchromesh gearbox
Explanation about the synchromesh gearbox

- This type of gearbox is similar to the constant mesh type gearbox.
- Instead of using dog clutches here synchronizers are used.
- The modern cars use helical gears and synchromesh devices in gearboxes, that synchronize the rotation of gears that are about to be meshed.

SYNCHRONIZERS

- This type of gearbox is similar to the constant mesh type in that all the gears on the main shaft are in constant mesh with the corresponding gears on the lay shaft.
- The gears on the lay shaft are fixed to it while those on the main shaft are free to rotate on the same.
• Its working is also similar to the constant mesh type, but in the former there is one definite improvement over the latter.
• This is the provision of synchromesh device which avoids the necessity of double-declutching.
• The parts that ultimately are to be engaged are first brought into frictional contact, which equalizes their speed, after which these may be engaged smoothly.
• Figure shows the construction and working of a synchromesh gearbox. In most of the cars, however, the synchromesh devices are not fitted to all the gears as is shown in this figure.
• They are fitted only on the high gears and on the low and reverse gears ordinary dog clutches are only provided.
• This is done to reduce the cost.
Contd....

- In figure A is the engine shaft, Gears B, C, D, E are free on the main shaft and are always in mesh with corresponding gears on the lay shaft.
- Thus all the gears on main shaft as well as on lay shaft continue to rotate so long as shaft A is rotating.
- Members F1 and F2 are free to slide on splines on the main shaft.
- G1 and G2 are ring shaped members having internal teeth fit onto the external teeth members F1 and F2 respectively.
- K1 and K2 are dogteeth on B and D respectively and these also fit onto the teeth of G1 and G2. S1 and S2 are the forks.
- T1 and T2 are the balls supported by spring.
Contd...

• These tend to prevent the sliding of members G1 (G2) on F1 (F2).

• However when the force applied on G1 (G2) slides over F1 (F2).

• These are usually six of these balls symmetrically placed circumferentially in one synchromesh device. M1, M2, N1, N2, P1, P2, R1, R2 are the frictional surfaces.

• To understand the working of this gearbox, consider figure which shows in steps how the gears are engaged.

• For direct gear, member G1 and hence member F1 (through spring-loaded balls) is slide towards left till cones M1 and M2 rub and friction makes their speed equal.
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• Further pushing the member G1 to left causes it to overdrive the balls and get engaged with dogs K1.
• Now the drive to the main shaft is direct from B via F1 and the splines.
• However, if member G1 is pushed too quickly so that there is not sufficient time for synchronization of speeds, a clash may result.
• Likewise defect will arise in case springs supporting the balls T1 have become weak.
Similarly for second gear the members F1 and G1 are slide to the right so that finally the internal teeth on G1 are engaged with L1.

Then the drive to main shaft will be from B via U1, U2, C, F1 and splines.

For first gear, G2 and F2 are moved towards left. The drive will be from B via U1, U2, D, F2 and splines to the main shaft. For reverse gear, G2 and F2 are slid towards right.

In this case the drive will be from B via U1, U2, U5, E, F2 and splines to the main shaft.
PERFORMANCE CHARACTERISTICS
• The above graph gives the relation between car speed and total resistance, tractive effort at the different gear ratios and different gradients.

• From the figure, the curves A to F are curves of total resistance for a road with uniform surface but of varying gradient,

• curve A being level and the curve F the steepest gradient.

• Curves RS, TU, VW are curves of tractive effort for three different types of gear ratios.

• Suppose the vehicle is traveling on the level at a speed represented by OX.

• Then resistance to be overcome is XY and XZ is the tractive effort available.

• The tractive effort available is therefore greater than the resistance to be overcome and the excess tractive effort YZ will go to increase the speed of the vehicle.
• Thus during acceleration, the resistance increases and extra effort for acceleration reduces. When the speed is OM, the total tractive effort is equal to total resistance. Thus speed cannot be increased further.
• If the vehicle now comes to a gradient to which the curve B applies. At the speed OM on gradient B, the resistance is MN.
• But tractive effort available is only MH. Thus excessive resistance MN will reduce speed of the vehicle to the point I where tractive effort is equal to the resistance
• Now suppose the gradient becomes steeper and steeper, so we pass in succession from curve B to C and so on. Then speed maintained lowers down to the points J, K etc.
• It is seen that we can traverse the gradient at any speed, since tractive effort at III gear lies everywhere below resistance curve.
• In such cases, the gear has to be shifted to second and the speed can be maintained at the point G.
Resistance to motion

Air resistance
Rolling resistance
Gradient resistance
Explanation about the resistance to motion

- The total resistance to the motion of a vehicle is the sum of three resistance namely Air resistance, Rolling resistance, Gradient resistance.

- It is thus composed of two parts that are independent of the speed of the vehicle - Rolling resistance, Gradient resistance & one part that is dependent on speed Air resistance.

- A curve of total resistance against speed is therefore obtained by shifting the curve of fig 1 up vertically by the amount of the rolling & gradient resistance as shown in fig 2.

- Thus when the speed is OS kmph, the total resistance SP, is composed of rolling resistance SR, gradient resistance RQ, & air resistance QP.

- If either the gradient resistance and (or) rolling resistance increases (or) decreases then the curve would simply shift up (or) down by the amount of the increases (or) decreases
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Traction and tractive effort

The force available at the contact between the rear wheel tyres and road is known as tractive effort. The ability of the rear wheels to transmit this effort without slipping is known as traction. Hence usable tractive effort will never exceed traction.

Engine torque, \( T_e = \frac{60000P_e}{2\pi N} \) N-m

Torque at rear wheels, \( T_w = (\text{g.r.} \times \text{a.r.}) \eta_1 \) \( T_e = G \eta_t \) \( T_e \)

Tractive effort, \( F = \frac{T_w}{r} = \frac{T_e G \eta_t}{r} \) N

\( P_e \) = engine b.p., KW
\( T_e \) = mean engine torque in N-m
\( \eta_t \) = overall transmission efficiency
\( \text{g.r.} \) = gear box gear ratio
\( \text{a.r.} \) = back axle ratio
\( G \) = overall gear ratio = (g.r. * a.r.)
\( R \) = radius of tyre in metre
\( N \) = r.p.m. of crank shaft

When the tractive effort \( F > R \), the total resistance on level road, the surplus tractive effort is utilized for acceleration, hill climbing and draw-bar pull.
GEAR BOX DESIGN

Power required to for propelling the vehicle \((P_v)\)

\[ P_v = \frac{RV}{3600} \text{ kw} \]

Where
\( V = \text{speed of the vehicle in km/hr} \)
\( \eta_t = \text{transmission or drive line efficiency} \)
\( R = \text{total resistance in N} \)
\( R_a = \text{air resistance in N} \)
\( R_r = \text{rolling resistance in N} \)
\( R_g = \text{grade resistance in N} \)
\( R = (R_a + R_r) \text{ when vehicle moves along a level road.} \)
\( R = (R_a + R_r + R_g) \text{ when vehicle moves up a gradient.} \)

Engine power required \((P_{req})\)

\[ P_{req} = P_v \frac{3600}{\eta_t} = \frac{RV}{3600\eta_t} \text{ KW} \]
Air resistance

\[ R_a = K_a A V^2 \]

Where

- \( A \) = projected frontal area, m\(^2\)
- \( V \) = speed of the vehicle, Km/hr
- \( K_a \) = coefficient of air resistance
  - 0.023 for best streamlined cars
  - 0.031 for average cars
  - 0.045 for trucks and Lorries

Rolling resistance

\[ R_r = K W \]

- \( W \) = total weight of the vehicle, N
- \( K \) = constant or rolling resistance and depends on the nature of road surface and types of tyres
  - 0.0059 for good surface
  - 0.18 for loose sand roads
  - 0.015, a representative value

Grade resistance

\[ R_g = W \sin \theta \]

- \( W \) = total weight of the vehicle, N
- \( \theta \) = inclination of the slope of the horizontal.
Relation between engine revolutions, \( N \) and Vehicle speed, \( V \)

\( N/V \) ratio depends upon the overall gear ratio. A vehicle having four different gears will have four different values of \( N/V \) ratio. \( V \) is km/hour and \( r \) is in metre.

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\frac{2\pi r N}{G} = \frac{1000 V}{60}
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N = \frac{1000 G}{V} = 2.65 \frac{G}{r}
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