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# 3-Speed Gearbox Mechanism

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***Abstract:*** *A gearbox is an important mechanical device used to transmit power and change the speed of a machine. This project deals with the design with the design and working of a 3-speed gearbox mechanism which provides three different speed ratios according to the requirement .The gearbox consists spur gears mounted on parallel shafts along with gear shifting mechanism to select the required speed .The main objective of this project is to achieve smooth speed variation ,simple construction ,and reliable operation .Basic design Calculations are carried out to determine gear ratios, speed, and torque transmission .A working model of the 3 speed gearbox is fabricated and tested to study its performance under different operating conditions .The results show that the gearbox efficiently transmits power and provides effective speed control .*

***Keywords -*** *3 Speed Gearbox, Gearbox Mechanism, Spur gears, Speed Variation, Power transmissions, Gear Shifting Mechanism, Mechanical System, Torque Transmission.*

## 1. INTRODUCTION

A 3 speed gearbox mechanism is a mechanical power transmission system used to provide three different speed ratios between the input and output shaft. It allows a machine are vehicle to operate efficiently under varying load and speed conditions vary. Such as during starting, acceleration, and highspeed running. By Allowing the operator to select different gear ratios, the gearbox ensures efficient power utilization, smooth operation, and reduced mechanical stress.

The gearbox mainly consists of an input shaft, layshaft (Countershaft), output shaft, gear pairs, bearings, selector mechanism, and a rigid housing. Each gear pair corresponds toa specific speed ratio. The gears are designed with accurate tooth profiles to ensure proper meshing, minimum power loss and reduced noise during operation.
The working principle of a 3speed gearbox is based on the selective engagement of gear pairs. When the input shaft rotates, power is transmitted to the layshaft through a constant mesh gear arrangement. Depending on the gear selected, a particular gear pair engages with the output shaft, providing the required speed and torque. The selection mechanisms may involve sliding gears, dog clutches or synchronizers, ensuring smooth and safe gear shifting. The three speeds are generally categorized as:

Low speed (First Gear): Provides high torque and low speed, used during starting or heavy load conditions.

Medium speed (Second Gear): Offers balanced torque and speed for normal operation.
High Speed (Third Gear): Delivers high speed with lower torque, used when load resistance is minimal.
From a production point of view, the gearbox components are manufactured using high-strength alloy steels to withstand dynamic loads and wear.

## 2.LITERATURE REVIEW

The gearbox mechanism plays an important role in transmitting power from the engine to the output shaft by varying torque and speed according to operating conditions. Earlier sliding mesh gearboxes required skilled operation and caused higher wear due to direct gear engagement. Modern research focuses on improving efficiency, compactness, durability, and smooth shifting performance.

Recent developments show that constant mesh and synchromesh gear systems are widely preferred in multi-speed gearboxes including 3-speed transmission systems. These mechanisms allow gears to remain continuously engaged while power transmission occurs through synchronizers or dog clutches, reducing noise and gear damage.

Advancements in Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) technologies enable accurate gear profile design, load analysis, and stress optimization. Modular gearbox design concepts improve flexibility and allow easier assembly, maintenance, and cost reduction. Research trends also emphasize lightweight materials such as alloy steels and improved heat treatment methods to increase strength and fatigue life.

Studies also highlight the importance of optimized gear ratios to achieve better torque multiplication at lower speeds and higher output speed at top gear. Improved lubrication systems and surface finishing methods reduce friction losses and increase transmission efficiency.

Modern manufacturing techniques such as CNC machining and precision grinding improve dimensional accuracy and reduce vibration during operation. Additionally, simulation software helps engineers analyze gear stress, load distribution, and efficiency before fabrication.

Recent industry research also focuses on compact multi-speed gearboxes for small vehicles, industrial machines, and educational mechanical models where simplified control mechanisms are required.

Thus, modern trends in gearbox design emphasize higher efficiency, smoother gear engagement, reduced noise, compact construction, and longer service life while maintaining economical manufacturing cost.

## 3.METHODOLOGY

PART A: CONSTRUCTION METHODOLOGY (IN DETAIL)

1.GEARBOX CASING

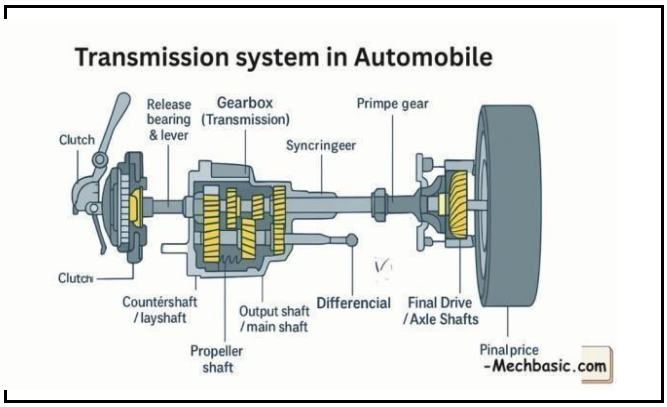
The Gearbox casing is the outer protective housing. It is generally made from cast Iron and aluminium alloy. Functions:

- Supports and aligns all internal components.
- Protects gears from dust, dirt, and damage.
- Acts as an oil reservoir for lubrication.
- The casing is designed to with stand vibrations and load Stresses.

2.INPUT SHAFT (DRIVING SHAFT)

The input shaft receives power from the engine, motor, or prime mover. It is mounted on ball or roller bearings to reduce friction. A constant mesh gear is rigidly fixed on the input shaft. This gear always remains engaged with the countershaft gear. Input shaft speed remains constant unless engine speed changes.

| **Gear** | **Counter Shaft Gear** | **Output Shaft Gear Result** |
|---|---|---|
| **1st small Gear** | **Larger gear** | **Low speed, high torque** |
| **2nd Medium Gear** | **Medium gear** | **Medium speed & torque** |
| **3rd Larger Gear** | **Small gear** | **High Speed & torque** |




3.COUNTERSHAFT (LAY SHAFT)

The countershaft is placed parallel to the input and output shafts. It carries three gears of different sizes fixed rigidly on it. These gears rotate together as a single unit. When the input shaft, rotates, the countershaft rotates continuously.

4.OUTPUT SHAFT (MAIN SHAFT)

The output shaft delivers power to the final drive or machine load. It contains three gears mounted freely on the shaft. These gears rotate independently until locked using a dog clutch. The shaft is supported by high quality bearings for smooth operation.

5.GEAR ARRANGEMENT

Three gear pairs are used:-

6.DOG CLUTCH MECHANISM

Dog clutches are mounted on splines of the output shaft. They slide axially to engage the selected gear. When engaged, the gear becomes locked to the shaft. Only one dog Clutch operates at a time. Purpose:

- Enables gear selection.
- Prevents power loss due to slipping.

7.GEAR SELECTOR MECHANISM

The gear selector consists of:

- Gear Lever

- Selector rods
- Selector forks

Movement of the gear lever shifts the selector fork. The selector fork slides the dog clutch into position. Ensures accurate and safe gear engagement.

8. BEARINGS

Bearings support all rotating shafts.

Type used:

- Ball Bearings
- Roller Bearings Functions:

- Reduce Friction
- Carry radial and axial Loads
- Increase gearbox Life

9.LUBRICATION SYSTEM

Gear oil is filled inside the casing.

Lubrication Methods:

- Splash lubrication
- Oil bath lubrication Functions:
- Reduces friction and wear
- Dissipates heat

PART B: WORKING METHODOLOGY (IN DETAIL)

10. POWER FLOW PATH

The general power transmission path is:
Prime mover -> Input shaft -> Counter shaft -> selected gear pair -> Output shaft

11.WORKING OF FIRST SPEED (LOW SPEED – HIGH TORQUE)

The gear lever is shifted to first speed position. The selector fork moves the dog clutch. Dog clutch locks the largest gear on the output shaft.

Power transmission:

- Input shaft drives countershaft
- Small countershaft gear drives large output gear Results:
- Output speed is reduced
- Torque is significantly increased Application:
- Starting condition
- Heavy Load operation

12.WORKING OF SECOND SPEED (MEDIUM SPEED – MEDIUM TORQUE)

Gear lever is shifted to second speed. Dog clutch disengages first gear and engages second gear. Medium-sized gears on both shafts transmit power.

Results:

- Moderate speed and torque.

Applications:

- Normal driving
- Moderate load conditions

13.WORKIING OF THIRD SPEED (HIGH SPEED – LOW TORQUE)

Gear lever is shifted to third speed. Dog clutch locks the smallest output shaft gear. Large countershaft gear drives small output gear.

Results:

- High output speed
- Lower torque

Applications:

- High-speed operation
- Light load conditions


Methodology Calculations of 3- Speed Gearbox Mechanism

The calculations methodology is used to determine gear ratio, output speed, torque, and power transmission efficiency for each gear stage.

1. Assumed Design Data ( Example )

For calculation purposes:

- Input motor speed ($N_1$) = 1440 rpm
- Motor power (P) = 1 HP (746 W) or according to project motor.
- Number of Gear Speeds = 3
- Gear type = Spur gear (Example)

2. Gear Ratio Calculation

Gear ratio depends on number of teeth.

Formula:

Gear ratio = Number of teeth on driven gear/ Number of teeth on driving gear

Example Gear Teeth Selection :

| Gear | Driving Gear Teeth | Driven Gear Teeth |
|---|---|---|
| First | 20 | 60 |
| Second | 30 | 45 |
| Third | 40 | 40 |

- First Gear Ratio:-
  $GR_1$= 60/20 = 3
- Second Gear Ratio:-
  $GR_2$= 45/30 = 1.5

- Third Gear Ratio:-
  $GR_3$= 40/40 = 1

3. Output Speed Calculation :

Formula:

Output Speed = Input Speed / Gear Ratio

- First Gear Speed:-
  $N_2$ = 1440/3 = 480 rpm
  ( Low speed – High torque )
- Second Gear Speed:-
  $N_2$= 1440/1.5 = 960 rpm
  ( Medium Speed )
- Third Gear Speed:-
  $N_2$= 1440/1 = 1440 rpm
  ( High Speed )

4. Torque Calculation:

Formula:

- Power=2πNT/60
  Rearranging:
  Torque= 60P/2πN

Input Shaft Torque:-

$T_1$ = 60×746 / 2π×1440

$T_1$ = 4.94 *N*m ( Approx )

5. Output Torque Calculation :

Torque increases with gear ratio.

Formula:

Output Torque = Input Torque × Gear Ratio

- First Gear Torque:-
  *T* = 4.94×3=14.82Nm
- Second Gear Torque:-
  *T* = 4.94×1.5=7.41Nm
- Third Gear Torque:-
  *T* = 4.94×1=4.94 Nm

6. Centre Distance Calculation

Formula**:**

$$Centre\ Distance = \frac{Module(Z_1 + Z_2)}{2}$$

Example:

Module = 2 mm

$$C = \frac{2(20 + 60)}{2}$$
$$C = 80mm$$

7. Power Transmission Efficiency

Assume gearbox efficiency = 90%.

Formula:

Output power = Input Power* Efficiency

746×0.9=671.4W

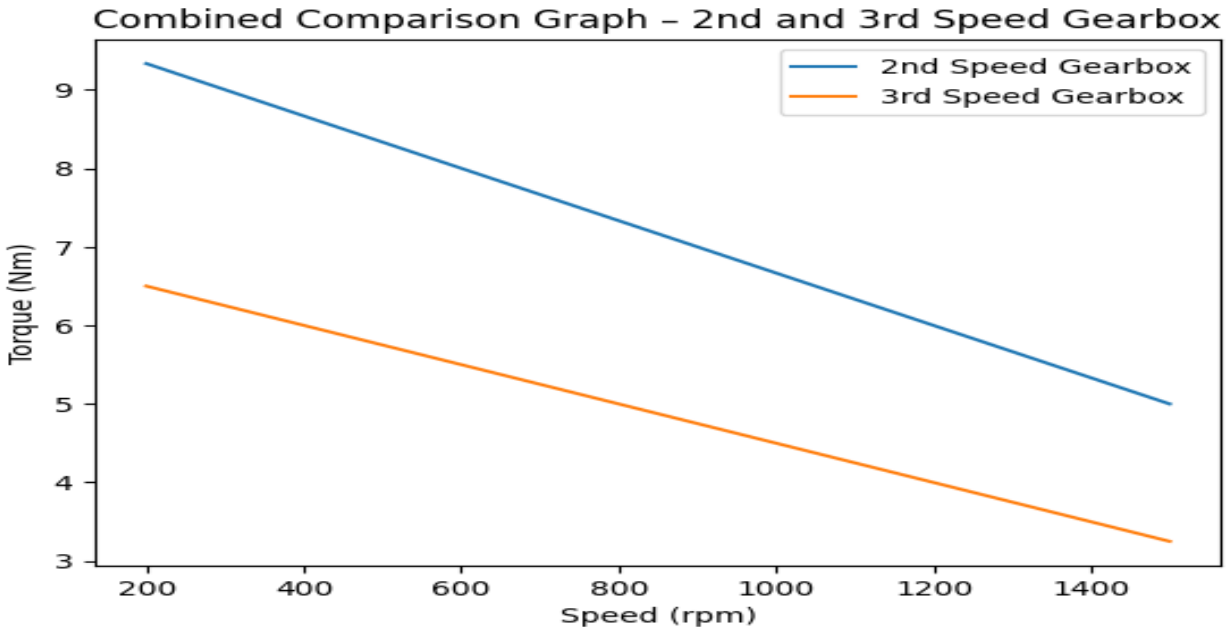
8. Summary Table :-

| Gear | Gear Ratio | Output Speed | Output Torque |
|---|---|---|---|
| First | 3 | 480 rpm | 14.82 Nm |
| Second | 1.5 | 960 rpm | 7.41Nm |
| Third | 1 | 1440rpm | 4.94Nm |

9. Conclusion of Calculation Methodology
The calculated gear ratios provide three different operating conditions:

- First gear produces high torque for starting loads.
- Second gear provides balanced performance.
- Third gear delivers high speed for light load operation.

10.Result:- Comparison Between 2nd and 3rd speed gearbox




## 4. CONCLUSION

The 3speed gearbox mechanism was successfully designed, fabricated, and tested. The mechanism effectively provides three different speed ratios with smooth power transmission and reliable operation. The result obtained from testing wear in closed arrangement with theoretical calculations. The simple construction and efficient performance make this gear suitable for light-duty applications and educational demonstration.

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