DESIGN AND ANALYSIS OF FIVE SPEED GEAR BOX WITH ITS DIFFERENTIAL UNIT

T.Gowtham[1]
S.Prasanth[2]
T.Balamurugan[3]
[1,2,3] B.E. Mechanical Engineering
Department of Mechanical Engineering
P.A.College of Engineering and Technology
Pollachi – 642 002, Coimbatore, Tamil Nadu, India.

Abstract

A machine consists of a power source and a power transmission system, which provides controlled application of the power. An assembly of parts including the speed-changing gears and the propeller shaft by which the power is transmitted from an engine to a live axle. A gearbox that uses gears and gear trains to provide speed and torque conversions from a rotating power source to another device. The most common use is in motor vehicles, where the transmission adapts the output of the internal combustion engine to the drive wheels. Such engines need to operate at a relatively high rotational speed, which is inappropriate for starting, stopping, and slower travel. The transmission reduces the higher engine speed to the slower wheel speed, increasing torque in the process. Transmissions are also used on pedal bicycles, fixed machines, and anywhere else rotational speed and torque needs to be adapted.

GEAR BOX

Often, a transmission will have multiple gear ratios with the ability to switch between them as speed varies. This switching may be done manually or automatically. Directional control may also be provided. Single-ratio transmissions also exist, which simply change the speed and torque of motor output. In motor vehicle applications, the transmission will generally be connected to the crankshaft of the engine. The output of the transmission is transmitted via driveshaft to one or more differentials, which in turn drive the wheels.

Fig 1.1. Common gearbox

TYPES OF GEAR BOX

The various types of gearboxes are for automobiles and other purposes are

1. Constant-mesh gearbox
2. Constant-load synchro-mesh
3. Baulk ring synchro-mesh
4. Alternative ratio gearbox
5. The all-indirect gearbox (transaxle)
6. Two-speed transfer gearbox

CONSTANT-MESH GEARBOX

The main feature is the use of the stronger helical of double helical gears which lead to quieter operation. In this design, the main shaft pinions revolves freely on bushes or needle-roller bearings and are all in constant engagement with the corresponding lay shaft wheels. The gear operation is obtained by locking the respective gear to the main shaft by means of a dog clutch.

CONSTANT-LOAD SYNCHRO-MESH

The figure shows unite main details of fundamentally the box is laid out in same manner as a constant-mesh, with the exception

that a cone clutch is fitted between the dog and gear members. The initial movement of the selector a sleeve carries the hub towards the gear and allows the cones adjusts the speed of the gearwheel to suit the hub and main shaft. Extra pressure on the lever will allow the sleeve to override the spring-loaded balls, and positively engage with the dogs on the gear.

BAULK RING SYNCHRO-MESH

This system is designed to overcome the main disadvantage of the earlier design- noise or crashing of the gears due to a quick change, by adding baulking ring to do the job as shown in the figure.

ALTERNATIVE RATIO GEARBOX

One arrangement is to provide two pairs of alternative-ratio constant mesh gears between the clutch shaft and lay shaft. This doubles the number of indirect gear ratios available. Another system is to use an auxiliary gearbox behind the main gearbox with a choice of direct drive or a reduction to split the ratios in the main gearbox. This enables all the available gears to be used in sequence. The auxiliary gearbox may be a lay shaft type with constant-mesh gears, or epicyclical, and the gear change may be power-operated electrically or by compressed air.

TWO-SPEED TRANSFER GEARBOX

A range of vehicles uses optional four-wheel drive- with additional 'emergency' low ratios- to provide a cross-country facility. This is usually accomplished by a two-speed transfer gearbox. With lay shaft and two pairs of constant-mesh helical gears, attached to the end of the main gearbox are driven via short coupling shaft from the gearbox main shaft.

FIVE SPEED GEAR BOX

An enclosed system of assembled gears that transmits mechanical energy from a prime mover to an output device. A gearbox can also change the speed, direction, or torque of mechanical energy. A five speed gearbox is a gearbox which can produce torque, speed of different variations. This kind of gear boxes can be used in automobiles with the use of a idler gear for reversing the speed. These gearboxes can be used in lathe for attaining speeds of different variations. Located at the junction point of a power shaft, the gearbox is often used to create a right angle change in direction, as is seen in a rotary mower or a helicopter. Each unit is manufactured with a specific purpose in mind and the gear ratio used is designed to provide the level of force required. This ratio is fixed and cannot be changed once the box is constructed. The only possible modification after the fact is an adjustment that allows the shaft speed to increase, along with a corresponding reduction in torque.

DESIGN OF FIVE SPEED GEAR BOX

The design is one of the most essential procedures for manufacturing a component. The design calculations are given below,

GEAR CALCULATIONS

Pitch diameter, D = m . z = 2x40 = 80mm
Module, M =D/Z=80/40=2
Outer diameter = (n+2)m= (40+2)2
= 84mm
Depth of cut = 2.25xm = 2.25x2
= 4.50mm
Tooth width = 1.5708m= 3.14mm
Indexing = 40/n= 40/40

SPEED CALCULATION

Distance from front of bell housing in inches	'N' 5 Speed
Overall length	30½
Speed output	24
Centre of lever opening	28¾
Underside mounting point	21
Weight	86 lbs

GEAR RATIOS

Gear	Gear ratios
1st	3.656:1
2nd	1.97:1
3rd	1.37:1
4th	1.000:1
5th	0.820:1

3.3.1. DESIGN AND DIAGRAMS

Fig 3.3.2. Spur gear (20 teeth)

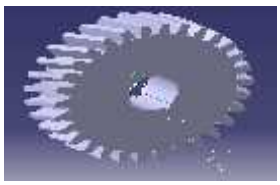

Fig3.3.3 Spur gear (30 teeth)

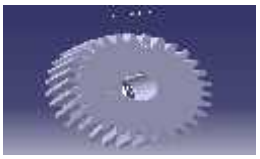

Fig3.3.4 Spur gear (35 teeth)

Fig3.3.5 Spur gear (40 teeth)

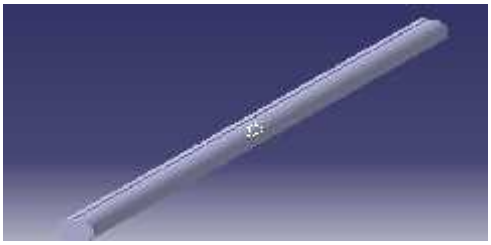

Fig3.3.6 Shaft

PROPERTIES OF CAST IRON

Carbon (C) and silicon (Si) are the main alloying elements, with the amount ranging from 2.1 to 4 wt% and 1 to 3 wt%, respectively. Iron alloys with less carbon content are known as steel. While this technically makes these base alloys ternary Fe-C-Si alloys, the principle of cast iron solidification is understood from the binary iron-carbon phase diagram.

PROPERTIES OF MILD STEEL

Mild steel is the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. Low carbon steel contains approximately 0.05–0.15% carbon and mild steel contains 0.16–0.29% carbon; making it malleable and ductile, but it cannot be hardened by heat treatment. Mild steel has a relatively low tensile strength, but it is cheap and malleable; surface hardness can be increased through carburizing. It is often used when large quantities of steel are needed, for example as structural steel.

OPERATIONS PERFORMED

The cast iron piece was taken and was mounted on the chuck of the three jaw center lathe and it was fixed. Carbide tipped tool was taken and fixed in the tool post for machining the work piece. The facing operation was performed on the chosen cast iron piece to get a smooth finish on the surface. facing operation was performed on all the ten cast iron pieces on both sides for the required dimensions.The material mild steel is faced at the edges for attaining smooth finish of the shaft.

Drilling

The diameter 19mm drill bit is taken and is fixed in the tailstock for performing the drilling operation. The faced workpieces are taken and is fixed in the chuck and the tailstock is moved towards the workpiece for drilling. The drill bit is placed on the workpieces and a drill is made. Thus drilling operation was performed on the workpieces.

Outer diameter turning

The drilled workpieces are fixed on the chuck with the help of a mandrel and a bolt. The workpieces on the mandrel are fixed on the chuck. The carbide tipped tool is used for outer diameter turning. The turning operation in performed on the workpieces.

Chamfering

The O.D turned workpiece is then chamfered on the inner edges and the outer edges using carbide tipped too to prevent the breakage of the workpieces on the edges.

The cast iron workpieces are then fixed on the chuck of the milling machine. Using the indexing plate the gear tooth is cut on the workpieces of varying diameters.The gear cutter work piece is then fixed in the slotting machine. Internal keyway is made on the gears by using the slotting machine.The shaft which is turned is then fixed on the vice of the vertical milling machine. The distances are marked and then the end mill cutter is fixed on the milling machine.

DESIGN AND DRAWINGS

FIVE SPEED GEARBOX COMPONENTS AND ITS SPECIFICATIONS

The six speed gearbox consists of the following components to full fill the requirements of complete operation of the machine.

MACHINE COMPONENTS

GEAR 1

No of gears: 3

Material : Cast iron.
Outer Diameter : 84 mm.
Thickness : 20 mm.
Bore diameter : 19 mm.

GEAR 2

No of gears: 2

Material : Cast iron.
Outer diameter : 64 mm.
Thickness : 20 mm.
Bore diameter : 19 mm.

GEAR 3

No of gears: 3

Material : Cast iron.
Outer diameter: 44 mm.
Thickness : 20 mm.
Bore diameter : 19 mm.

GEAR 4

No of gears:1

Material : Cast iron.
Outer diameter : 54 mm.
Thickness : 20 mm.
Bore diameter : 19 mm.

GEAR 5
No of gears: 1

Material : Cast iron.
Outer diameter : 74 mm.
Thickness : 20 mm.
Bore diameter : 19 mm.

SHAFTS
No of shafts: 3

Material : Mild steel.
Diameter : 19 mm.
Thickness : 20 mm.
Length : 400 mm.

MERITS AND APPLICATIONS

High speed transmission can be achieved.

Speeds up to four times the input can be achieved by using this gearbox.

Since there is no slip, so exact velocity ratio is obtained

It is more effective and efficient means of transmission.

The gear box is smoother and quieter in operation.

It is used for lathe and milling machines.

It is used in machines where high torque is required.

FACTORS DETERMINING THE CHOICE OF MATERIALS

The various factors which determine the choice of material are discussed below

PROPERTIES

The Material selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be Strength, Surface finish, rigidity, Chemical stability, etc. The following four types of principle properties of materials decisively affect their selection:

- Physical.
- Mechanical
- From Manufacturing Point of View
- Chemical.

The Various Physical properties concerned are melting point, thermal conductivity, specific heat, and co efficient of thermal expansion, specific gravity, electrical conductivity, magnetic properties etc. the various mechanical properties concerned are strength at various loads such as tensile, compressive, shear, bending, torsion, impact, dead, gradual loads, hardness, wear resistance and sliding properties.

MANUFACTURING CASE

Sometimes the demand for lowest possible manufacturing cost or surface qualities obtainable by the application of suitable coating substance may demand the use of special materials.

QUALITY REQUIRED

This generally affects the manufacturing process and ultimately the materials. For example it would never be desirable to go for casting of a less number of components which can be fabricated much more economically by welding or hand forging the steel.

AVAILABILITY OF MATERIAL

Some material may be source or in short supply. It then becomes obligatory for the designer tom use some other material which though may not be a perfect substitute for the material designed. The delivery of material and delivery date of product is also kept in mind.

SPACE CONSIDERATION

Sometimes high strength material should be selected because the forces involved high and space limitations are there.

BILL OF MATERIALS

S.NO	DESCRIPTION	MATERIAL	QUANTITY
1.	Gear wheel.	Cast iron.	10.
2.	Shaft.	Mild steel.	3.
3.	Bearing	Mild steel.	6.
4.	Key	Mild steel.	1.
5.	Circle pin	Mild steel.	10.
6.	u-clamp	Mild steel.	3.
7.	Outer box	Wood.	-

DIFFERENTIAL

A differential is a device, usually, but not necessarily, employing gears, which is connected to the outside world by three shafts, chains, or similar, through which it transmits torque and rotation in automobiles and other wheeled vehicles, a differential is the usual way to allow the driving road wheels to rotate at different speeds. This is necessary when the vehicle turns, making the wheel that is travelling around the outside of the turning curve roll farther and faster than the other. The engine is connected to the shaft rotating at angular velocity. The driving wheels are connected to the other two shafts, and are equal. If the engine is running at a constant speed, the rotational speed of each driving wheel can vary, but the sum (or average) of the two wheels' speeds can not change. An increase in the speed of one wheel must be balanced by an equal decrease in the speed of the other. (If one wheel is rotating backward, which is possible in very tight turns, its speed should be counted as negative.)

Ratios: The ratio of speeds between gears is dependent upon the ratio of teeth between the two adjoining gears such that $\mathbf{w}_1 \times \mathbf{N}_1 = \mathbf{w}_2 \times \mathbf{N}_2$, where w is the respective angular velocity, and N = the number of teeth on the gear.

***Velocity*:** When two gears are in contact and there is no slipping, $v = w_1 \times r_1 = w_2 \times r_2$, where v is the tangential velocity at the point of contact between the gears, and r is the respective pitch radius of the gear. In a differential, since the speed transmitted by the crown gear is shared by both of the wheels (not necessarily traveling at the same speed),

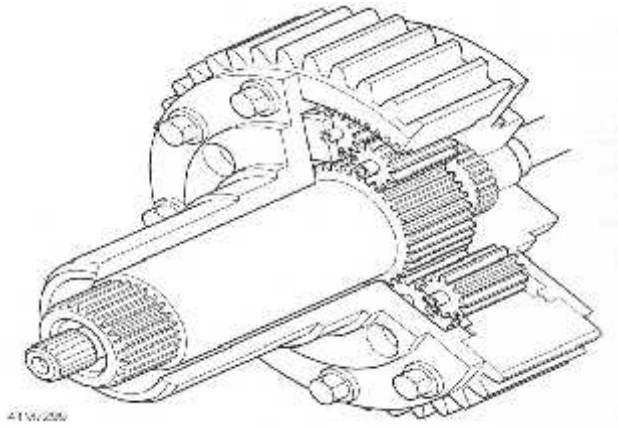

Fig 5.2.1 Differential unit

CONCLUSION

This project provides an excellent opportunity to improve our skill and knowledge in planning; controlling, purchasing, machining, coordinating, computing and difficulties arise in designing and fabricating a five speed gear box. We feel that the project work is a good

solution to bridge the gates between institution and industries.We have completed our projects successfully within the give time. The "Five Speed Gearbox" will be very useful in large scale and small scale industries and will reduce human fatigue. It is also very economical when compare it other types of gearbox.

FUTURE SCOPE

The future scope of this project is that it can be used in machines which require high torque and speed. It can be used in machines such as lathes, milling machine and in all kinds of machines where a change of speed is required.

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