UNIT 5  FINAL DRIVE

Structure

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5.1 INTRODUCTION

The power developed by the engine is transferred to the wheels through clutch, gear box, universal joints, propeller shaft, final drive, differential and rear axles. Description of universal joints, propeller shaft, final drive, differential and rear axles has been given in this unit.

Objectives

After studying this unit, you should be able to

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- , and
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5.2 UNIVERSAL JOINTS

Universal joint is used to connect two shafts at an angle for transmitting torque. In the transmission shaft of an automobile, two universal joints are used – one between main transmission shaft and propeller shaft and another between other end of propeller shaft and the differential. Therefore, the universal joints make the joints flexible so that power can be transmitted at an angle.

A universal joint takes care of rising and falling motion of the rear end of the propeller shaft which is connected to differential. Two universal joints are shown in Figure 5.1 along with the propeller shaft.
5.3 TYPES OF UNIVERSAL JOINTS

Three types of universal joints are commonly used. These are listed below:

(a) Cross or spider joint (variable velocity joint).
(b) Ball and trunnion joint (variable velocity joint).
(c) Constant velocity joints.

Cross Type Universal Joint

It consists of two Y-shaped yokes and a cross piece (spider). One yoke is connected to driving shaft and other is connected to driven shaft. The cross-piece has four-arms which are known as trunnions and are attached to the ends of yokes. Four needle bearings are provided – one for each arm of cross-piece. These bearings allow the yoke to swing around the trunnion when driving and driven shaft remove together at an angle. A simple cross-type universal joint is shown in Figure 5.2.

Ball and Trunnion Joint

This type of joint consists of a ball type head which is fastened to one end of the propeller shaft. A pin is also pressed through this end of shaft. Two steel balls are fitted at the end of this pin. The joint facilitates rotary motion through ball and pin. The balls can also move axially.

Ball and trunnion joint is also a variable velocity joint.

Constant Velocity Universal Joint

This type of joint permits movement of both driving and driven shafts at constant velocity. Because, two joints in this case operate at same angles. These joints are generally used when the automobile in a front wheel (axle) drive. Because speed variation between driving and driven shaft will introduce difficulty in steering and excessive tyre wear.
5.4 PROPELLER SHAFT

The propeller shaft is a shaft that transmits power from transmission (gear box) to the differential. On one end, propeller shaft is connected to main transmission shaft by universal joint. On the other hand, it is connected to differential pinion shaft by another universal joint. Propeller shaft transmits the rotary motion of main transmission shaft (coming from gear box) to the differential so that rear wheels can be rotated. A sliding (slip) joint, is also fitted between universal joint and propeller shaft on transmission side which takes care of axial motion of propeller shaft. Propeller shaft is made of a steel tube which can withstand torsional stresses and vibrations at high speeds.

It is important to note that the differential pinion shaft and transmission main shaft are not in single horizontal level. The rear axle and differential is attached to automobile frame via springs. Therefore, distance between differential and gear box keeps on changing as vehicle moves along irregular road surface. Angle of propeller shaft also changes due to this fact. Universal joints provided at two ends takes care of these two changes. The propeller shaft along with universal joints has been shown in Figure 5.3.

![Figure 5.3 : Propeller Shaft](image)

A slip joint is provided between universal joint and propeller shaft to adjust for any change in length.

5.5 FINAL DRIVE OR FINAL REDUCTION

Final drive is the last stage of power transfer from propeller shaft to rear (or front if – automobile is front wheel driven) axles and then to wheels. It turns the propeller shaft motion at right angle to drive the rear axle.

The final drive is composed of a bevel gear (or pinion) and crown wheel. The level pinion is connected to propeller shaft. The pinion is in mesh with the crown wheel. Crown wheel is part of differential. Final drive provides fixed speed reduction. Because the crown wheel has more number of teeth and it is connected to rear axles and level pinion has less number of teeth. Schematic diagram of final drive has been given in Unit 1.

For final reduction in speed two types of gears can be used. One of them may be use of level gears and another may be worm and worm wheel. Worm and worm wheel combination provides large reduction without employing larger gears. It is strong also.

**Slip Joint**

The rear axle housing with wheel and differential is attached to the frame of automobile through springs. As the vehicle moves over uneven surface, this whose assembly moves up and down due to expansion and compression of springs. This changes the length of propeller shaft because it is connected to differential and gear box. Slip joint (Figure 5.3) allows for the change in length of propeller shaft. When spring is compressed propeller shaft shortens and when spring is expanded, propeller shaft returns to original length.
When a four wheeler (car) takes a turn, the outer wheel turns faster than inner wheel. Thus, there is relative movement between inner and outer wheel. The function of the differential is to permit the relative movement between inner and outer wheels when vehicle negotiates (takes) a turn. The torque transmitted to each rear wheel is equal in this case, although their speed is different.

The differential is made up of a system of gears which connect the propeller shaft and rear axles. It is a part of inner axle housing assembly. The assembly consists of differential, rear axles, wheels and bearings.

Construction and Working

The construction of a simple differential is shown in Figure 5.5. It consists of sun gears, planet pinion, a cage, a crown wheel and a bevel pinion. A sun gear is attached to inner end of each rear axle (half shaft). A cage is attached on left axle. A crown gear is attached to the cage and the cage rotates with the crown gear. The crown gear is rotated by the bevel pinion. Crown gear and cage remain free on the left rear axle. Two planet pinions are on a shaft which is supported by the cage. The planet pinions mesh with the sun gears. The rear wheels are attached to outer ends of two rear axles. When the cage rotates, sun gears rotate. Thus, the wheels also rotate. In case one inner wheel runs slower than other when the vehicle takes a turn, the planet gears spin on their shaft, transmit more rotary motion to outer wheel. When vehicle runs in straight line, the crown gear, cage, planet pinions and sun gears turn together as a unit. Thus there is no relative motion.

5.7 TYPES OF DIFFERENTIAL

There are three types of differential:

(a) Conventional type,
(b) Non-slip or self locking type, and
(c) Double reduction type.
Conventional Type

Conventional type differential described in Section 5.6 delivers same torque to each rear wheel. If any of the wheels slips due to any reason the wheel does not rotate and vehicle does not move.

Non-slip or Self Locking Type

Non-slip or self locking type differential overcomes this drawback. It construction is similar to that of conventional type differential. But, two sets of clutch plates are provided additionally. Also, the ends of planet shafts are left loose in notches provided on the differential cage.

Double Reduction Type

Double reduction type differential provides further speed reduction by additional gear. This type of differential is used in heavy duty automobiles which require larger gear reduction between engine and wheels.

5.8 REAR AXLES

Rear axle transmits power from differential to the wheels so that vehicle may move. Rear axle is not a single piece but it is in two parts which are connected by the differential. This is shown in Figure 5.5. Each part of rear axle is called the half shaft. Outer end of the rear axle carries the wheel while inner end is connected to sun gear of the differential. In vehicles which employ rear wheel drive, rear wheels are driving wheels. However, in front wheel drive vehicles, front wheels are driving wheels. Rear axles and differential are completely enclosed in a housing to protect them from dust, dirt, water and any possible damage.

Functions of Rear Axle

(a) To transmit power from differential to the wheels. This is main function.
(b) To carry weight of automobile.

5.9 TYPES OF REAR AXLES

Rear axles differ on the basis of method of supporting them and mounting of rear wheels. On this basis, these axles can be classified into three types:

(a) Half floating axle shown in Figure 5.6.
(b) Three-quarter floating axle shown in Figure 5.7.
(c) Fully floating rear axle shown in Figure 5.8.

Half Floating Axle

In a half floating rear axle, the axle is at the centre of the axle casing and the bearings are inside the axle casing. The weight of vehicle is transmitted first to suspension spring, then to axle casing, then to axle and finally to ground.
Three-quarter Floating Axle

In three-quarter floating rear axle, bearings are on the outer side of axle casing, i.e. between casing and wheel. In this case, major part of vehicle weight is taken by axle casing and not by axle. This is the main advantage of three-quarter floating type over half floating type. Thus, axle breakdown is less in this case compared to the previous type.

Figure 5.7 : Three-quarter Floating Rear Axle

Fully Floating Rear Axle

In fully floating rear axle, the bearings are provided between axle casing and the wheel. In this case, all the vehicle weight is transmitted to ground through axle case and wheel. The axle is not supported by bearings but it is supported at both ends. This type of axle is very strong and therefore, it is used for heavy duty vehicles. In the event of breakdown of axle, wheel cannot come out. This, it is safer but costly.

Figure 5.8 : Full Floating Rear Axle

SAQ 1

(a) What is the function of an universal joint? Where it is used in the transmission system of an automobile?

(b) List different types of universal joints and describe the construction and features of cross type joint.

(c) What is the function of propeller shaft? How it is connected in the transmission system?

(d) Why is slip joint used with the propeller shaft?

(e) Write the function of final drive.
SAQ 2

(a) What is the purpose of using a differential in an automobile?
(b) Describe the working of differential.
(c) Why rear axle is in two halves?
(d) List various type of rear axles and describe the working of half or semi-floating rear axle.
(e) Which type of rear axle is used for heavy duty (load) vehicle?

5.10 SUMMARY

5.11 KEY WORDS

5.12 ANSWERS TO SAQs

Refer the preceding text for all the Answers to SAQs.