EXPERIMENT NO.1

AIM : To study and prepare report on the constructional details, working principles and operation of the following Automobile clutches:

a) Coil Spring Clutch
b) Diaphragm Spring Clutch
c) Multi plate Clutch

T H E O R Y

Constructional Details, Working Principle and Operation of the above

Friction plate is held between the flywheel and the pressure plate. There are springs (the number may vary, depending upon design) arranged circumferentially, which provide axial force to keep the clutch in engaged position. The friction plate is mounted on a hub which is splined from inside and is thus free to slide over the gear box shaft. Friction facing is attached to the friction plate both sides to provide two annular friction surfaces for the transmission of power. A pedal is provided to pull the pressure plate against the spring force whenever it is required to be disengaged.

When the clutch pedal is pressed, the pressure plate is moved to the right against the force of the springs. This is achieving by means of a suitable linkage and a thrust bearing. With this movement of the pressure plate, the friction plate is released and the clutch is disengaged.

In actual practice the construction of the clutch differs. The pressure plate, the springs, the release levers and the cover form a sub assembly, called the cover assembly which can be mounted directly to the engine block, of course, placing the clutch plate in between the flywheel and the pressure plate with the clutch shaft inserted in this arrangement.

A d v a n t a g e s

1 With the single plate clutch, gear changing is easier than with the cone clutch, because the pedal movement is less in this case

2 It does not suffer from disadvantages of cone clutch i.e. bindings of cones etc. and hence it is more reliable

D i s a d v a n t a g e s

As compared to cone clutch, the springs have to be more stiff and this means greater force require to be applied by the driver while disengaging.

In the assembled position releases lever rest against the centre opening of the cover pressing there is an eyebolt nut which causes the strut to pull the pressure plate against the springs, thus holding together the assembly. When the cover is bolted onto the flywheel, the pressure plate is further pushed back against the springs,

causing them to be compressed further, which relaxes the release levers. Anti rattle springs serve to prevent the undesirable noise due to release levers when the clutch is in the engaged position.

Diaphragm Spring Type Single Plate Clutch

The construction of this type of clutch is similar to that of the single plate type of clutch described above except that here diaphragm springs (also called Belleville springs) are used instead if the ordinary coil springs. In the free condition, the diaphragm spring is of conical form but when assembled, it is constrained to an approximately flat condition because of which it exerts a load upon the pressure plate.

It is seen from the above figures that the diaphragm spring is supported on a fulcrum retaining ring so that any section through the spring can be regarded as a simple lever. The pressure plate E is movable axially, but it is fixed radically with respect to the cover. This is done by providing a series of equally spaced lugs cast upon the back surface of the pressure plate. The drive from the engine flywheel is transmitted through the cover, pressure plate and the friction plate to the gear box input shaft.

The clutch is disengaged by pressing the clutch pedal which actuates the release fingers by means of a release ring. This pivots the spring about its fulcrum, relieving the spring load on the outside diameter, thereby disconnecting the drive.

In this clutch, three straps of spring steel are placed equilaterally so that their outer ends are riveted to the cover, while their centers are riveted to the pressure plate. Drive is transmitted from the cover to the pressure plate via the straps along lines of action through the strap rivet centers. Spring flexure of the straps permits the axial movement of the pressure plate relative to the cover.

Advantages of the diaphragm spring type clutch

This type of clutch has now virtually superseded the earlier coil spring design in many countries in clutch sizes ranging upto 270 mm, in diameter, although in case of heavy vehicles, the coil spring type clutches are still being used because of the difficulty to provide sufficient clamping force by a single diaphragm spring. The diaphragm spring however, offers certain distinct advantages.

i) it is more compact means of storing energy. Thus compact design results in smaller clutch housing.

ii) As the diaphragm spring is comparatively less affected by the centrifugal forces, it can withstand higher rotational speeds. On the other hand, coil springs have tendency to distort in the transverse direction at higher speeds.

iii) In case of coil springs, load deflection curve is linear. Therefore, with the wear of the clutch facing the springs has less deflection due to which they would apply less force against the clutch plate. On the other hand, in case of diaphragm spring, the load deflection curve is not linear therefore, in this case, as the clutch facing wears, force on the plate gradually increases, which means that even in the worn out condition, the spring force is not less than its value in case of new clutch. Further, it is also seen that the load deflection curve depends upon the ratios h/t where h is the free dish height and t is the thickness of the spring. Therefore, in this case with suitable design, the load deflection curve can be improved to give lower release loads.

iv) The diaphragm acts as both clamping spring and release levers. Therefore, many extra parts like
struts, eye bolts, levers etc. are eliminated in the diaphragm spring, because of which the loss of efficiency due
to friction wear of these parts also does not occur, which results in the elimination of squeaks and rattles.

Multiplate clutch

These clutches are used in heavy commercial vehicles, racing cars and motor cycles for transmitting high torque. In comparison to single plate type, these switches are smoother and easier to operate due to their assembly of friction surfaces contact. They may be used where space is very limited, i.e. in automatic transmission and motor cycles. In the latter cases a multiplate clutch of small operator transmits approximately the same torque as a single plate clutch of twice that diameter. These are also used in cases where very large torques are to be transmitted i.e. in heavy commercial vehicles, cars, special purpose military and agricultural vehicles. These clutches may be dry or wet. When the clutch of this type is operated in a bath of oil, it is called a wet clutch. But these oil immersed or wet clutches are generally used in conjunction with or as a part of the automatic transmission. It consists of a number of thin plates connected alternately to input and output shaft resulting in a very large area of working surface in a comparatively small space. The increased number of plates provides the increased torque transmitting ability of the clutch.

EXPERIMENT NO.2

AIM : To study and prepare report on the constructional details, working principles and operation of the following Automotive Transmission Systems:

a) Sliding Mesh
b) Constant Mesh
c) Synchromesh - four speed range

Sliding Mesh type Gear Box

The power is transferred from the engine to the clutch shaft and then to the clutch gear which is always in mesh with a gear on the layshaft. All the gears on the lay shaft are fixed and as such they are all the time rotating when the engine is running and the clutch is engaged. Three direct and one reverse speeds are attained by suitably moving the gear on the main shaft by means of selector mechanism.

Constant Mesh Gear Box

In this type of gear box, all the gears are in constant mesh with the corresponding gears on the layshaft. The gears on the main shaft which is splined, are free. The dog clutches are provided which slide on the main shaft. The gears on the layshaft are, however, fixed.

When the left dog clutch is slided to the left by means of the selector mechanism, its teeth of the gear are engaged with the clutch gear. The same dog clutch, however, when slide to right makes contact with the second gear and second gear ratio is obtained. Similarly movement of the right dog clutch to the left results in low gear and towards right in reverse gear.

Synchromesh Gear Box

This type of gear box is similar to the constant mesh type. In this all the gears on the mainshaft are in constant mesh with the corresponding gears on the layshaft. The gears on the layshaft are fixed to it while those on the mainshaft are free to rotate on the same shaft. 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 which ultimately are required to be engaged, are first brought into frictional contact which equalizes their speed, after which these may be engaged smoothly.

In most of the cars, however, the synchromesh devices are not fitted to all the gears. They are only on the high speed gears but on the low speed and reverse gears, ordinary dog clutches are only provided. This is done to reduce the cost.
In other words, the gear wheels which are to be positively connected are first brought into frictional contact and when the friction has equalized their speeds, the positive connections are made. Synchromesh devices can be applied to the sliding mesh gear box but they are universally used with constant mesh gear boxes used in different motor vehicles. The main features of this gear box are:

a) The output gears are free to rotate on bushes on the output shaft. They are internally located by splined thrust bearings. Single or double helical gears remain in constant mesh with the lay shaft gears.

b) The output gears are locked to their shaft by the dog clutch
c) Change of the synchronizing hub takes place when its speed equalizes or synchronizes by theirs cones.

In case this gear is not used, it is left to the skill of the driver to bring one or more gears for meshing. By the skillful use of this clutch and accelerator pedal, he can bring the gears approximately the same speed. Even for the unskilled driver it is not difficult to affect quite satisfactory the change of gears. He can do it simply by using the clutch pedal gear lever with the help of successful commercial gear synchronizers.

EXPERIMENT NO. 3

AIM : To study and prepare report on the constructional details, working principles and operation of the following automotive tyres and wheels.

a) Various types of Bias & Radial Plies Tyres
b) Various types of Wheels

Disc wheel

This type of wheel consists of two parts, a steel rim which is base to receive the tyre and a pressed steel disc. The rim and the disc may be , permanently attached or attachable, depending upon design.

When the bead of the tyre is rests in the rim, it becomes possible to fit in position of the rim. Without the well it would not be possible to mount or remove the tyre from the wheel. The seat of the rim where the tyre rests usually has a 5 degree or 15 deg taper (not shown) so that as the tyre is inflated, the beads are forced up the taper to give a wedge fit. With tubeless tyres, the taper helps to build a good seal.

The steel disc performs the functions of the spokes. The wheel hub is fitted on the axle. Some slots are generally provided in the wheel disc to allow the air to pass to the inner side for better cooling of the brake drum inside. Since these holes tend to weaken the disc, the holes in modern wheels are swaged which means that some portion of the disc around each hole is turned inward smoothly to compensate for the loss of strength due to holes. A separate cover is also provided on the wheel disc. A hole in the rim serves to accommodate tube valve.

A wheel may be inset, zero set or outset, depending upon the position of the rim in relation to attachment face of the disc. In the inset wheel the centre line of the rim is, located inboard of the attachment face of the disc. Inset is distance the distance from the attachment face of the disc to the centre line of the rim. A zero set wheel is the one in which the rim centre line coincides with the attachment face of the disc while in the outset wheel the centre line of the rim is located outboard of the attachment face of the disc. A wheel whose disc can be mounted on either face to provide inset or outset, thus decreasing or increasing the wheel track is called reversible wheel. Wheel constructed in two parts, which when securely fastened together combine to form a rim having two fixed flanges is called a divided wheel rim.

Wire Wheel

Unlike the disc wheel the wire wheel has a separate hub which is attached to the rim through the number of wire spokes. The spokes carry the weight, transmit the driving and braking torques and withstand the side forces while cornering, in tension. Spokes are long, thin wires and as such these can not take any compressive or bending stresses. All types of loads are sustained by the spokes in tension .The spokes are mounted in a complicated criss-cross fashion installed in the three planes. The component of vehicle weight in the direction of spokes above the hub is sustained by these spokes in tension. Similarly, the driving and the braking torques are taken up by the tension in the spokes in the desired direction as shown by fig respectively. The side forces on cornering are taken up by the spokes forming triangular arrangement. Thus it is seen that the spokes have to be mounted on the wheel. The initial tension of the spokes can be adjusted by means of screw nipples which

also serve to secure the spokes to the rim. The hub is provided with internal splines to correspond to the splines
provided on the axle shaft. A wing nut screws the hub on the axle shaft. The advantages of this type of wheel
are light weight and high strength, and above all it provides much better cooling of the brake drum. It is also easy to change the wheel when required, because only one nut has to be opened. However, wire wheels are
expensive due to their intricate construction. The rim of a wired wheel is not capable to fit tubeless tyres.

Light alloy cast or forged wheel

The latest trend in case of automobile wheels is the use of wheels made from aluminum or magnesium alloys
cast wheels are generally used for cars while forged wheels are preferred for wheels of heavier vehicles. The
main advantage of light-alloy wheels is their reduced weight which reduces unsprung weight. A magnesium alloy wheel weighs about 50 per cent of a steel wheel and about 70 per cent of an aluminum alloy wheel for
similar strength. Moreover, light alloys have better conductivity of heat which helps the wheels to dissipate
heat generated by the tyres or brakes and thereby run cooler. Further, wider rims improve stability on
cornering. Through cast or forged wheels have to be machined, yet this helps to maintain close tolerances and
also produce better appearance. Magnesium alloys have high impact and fatigue strength so that they can stand
vibrations and shock loading better. However, being tune to corrosion, these have to be given some protective
coating. Aluminum alloys do not have high resistance to vibration and shock as in case of magnesium alloys,
but these are relatively easier to cast or forge and also less tune to corrosion. Generally, aluminum alloys are
used for cars sports and racing cars usually have magnesium alloy wheels. Higher cost is the only
disadvantage of light alloy wheels.

Wheel styling being a modern trend in automotive industry, wheel division of Dunlop Limited has designed a range of wheels of cast aluminum alloy and designated this range as Formula D This range also includes composite wheels, i.e. the wheels with cast aluminum body alloy and steel rims.

Tyre

A tyre is a cushion provided with an automobile wheel. It consists of mainly the outer cover i.e the tyre and the tube inside. The tyre tube assembly is mounted over the wheel rim. It is the air inside the tube that carriers the entire load and provides the cusion. .

The tyre performs the following functions

1 Supports the vehicle load
2 Provides cushion against shocks
3 Transmits driving and braking force to the road
4 Provides cornering power for smooth steering

Tyre Properties

Non skidding

This is one of the most important tyre properties. The tread pattern on the tyre must be suitably designed to permit least skidding even on wet roads.

Uniform wear

To maintain the non skidding property, it is very essential that the wear of the tyre treat must be uniform. The ribbed tread pattern helps to achieve this.

Load carrying capacity

The tyre is subjected to alternating stresses during each revolution of the wheel. The tyre material and design must be able to ensure that the tyre sustains the stresses.

Cushioning

The tyre should be able to absorb high frequency vibrations set up by the road surface and thus provide cushioning effect

Power consumption

The automotive tyre should absorb some power which is due to friction between the tread rubber and road surface and also due to hysterics loss on account of the tyre being continuously fixed and released. This power comes from the engine and should be least. It is seen that the synthetic tyres consume more power while rolling than the ones made out of natural rubber.

Tyre noise

The tyre noise must be in the form of definite pattern, a sequel or a loud roar. In all these cases, it is desirable that the noise should be minimum.

Balancing

Balancing is very important consideration for tyres. The tyre being a rotating part of the automobile, it must be balanced statically as well as dynamically. The absence of balancing gives rise to peculiar oscillations called wheel tramp and wheel wobble.

Types of tyres

The use of solid tyres in automobiles is almost obsolete and only the pneumatic tyres are used universally. These pneumatic tyres are of two types viz. the conventional tyre with a tube and the tubeless tyre.

Conventional Tube tyre

Fig gives in a simplified form the cross section of such a tyre. It consists of two main parts, viz. the carcass and the tread. The carcass is the basic structure taking mainly the various loads and consists of a number of plies wound in a particular fashion from the cords of rayon or any other suitable material. Each cord in each ply is covered with resilient rubber compounds and all the plies are insulated against each other. The term ply rating which is often used in tyre industry does not indicate exact number of plies in the tyre. It is only a relative index of tyre strength and load carrying capacity. A four ply rating tyre, may have only two plies. In order to prevent the tyre from being thrown off the rim, the plies are attached to two rings of high tension steel wire. These rings are made to fit snugly against wheel rim thereby anchoring the tyre to the rim. These rings are called beads.

The tread is the part of the tyre which contacts the road surface when the wheel rolls.It is generally made of synthetic rubber and the design of the tyre tread depend on various tyre properties viz the grip, the noise and the wear. The tread is moulded into a series of grooves and ribs. The ribs prove the traction edges required for gripping the road surface while the grooves provide passage for quick escape of any foreign matter such as water etc. Traction edges and sipes are provided on the ribs. Sipes are the small groves moulded into the ribs of the tyre tread, these increase the traction ability of the tyre by increasing number of traction edges. As the tyre flexes on the road surface, the sipes open to provide extra gripping action. The sipes appear to be shallow but in fact these travel the entire depth of the tread. The design of the tyre tread has a direct effect on the tyre life, its handling characteristics, quality of ride comfort, noise, and traction. Between the head and the tread the outer rubber covering of the carcass is called side wall. The sidewalls are designed to flex and bend without cracking when subjected to continuous deflection while running. In other words, the sidewall material must have high fatigue strength. At the inner edges, beads are formed by reinforcing with steel wires. This provides the tyre with strong shoulders for bearing against the wheel rim. All plies are tied to the beads which prevent any change of shape.

Inside the tyre, there is a tube which contains the air under pressure. The tube being very thin and flexible,
takes up the shape of the tyre cover when inflated. A valve stem is attached to the tube for inflating or deflating
the same.

Tubeless tyre

This type of tyre does not need a separate tube; instead the air under pressure is filled in the tyre for which purpose a non-return valve is fitted to the rim. The inner construction of the tyre is almost same as that of tube tyre, except that it is lined on inside with a special air-retaining liner.

The tubeless tyres possess following advantages over the conventional tubed tyres.

1. Lesser upsprung weight - being lighter, unsprung weight is reduced, and ultimately reduces wheel bouncing.
2. Better cooling - In case of tube tyres, heat in the compressed air has to pass through the tube material, i.e. rubber, which is not a good conductor of heat. Since there is no tube in the tubeless tyres, hence heat passes to the atmosphere directly resulting better cooling thereby increasing the tyre life.
3. Slower leakage of air - since the inner liner in the tubeless tyres is not stretched like the tube, it retains the air better resulting in its slower leakage.
4. Simpler assembly - Only the tyre has to be fitted over the rim. There is no danger of the tube being punctured during assembly.
5. Improved safety - In case of any tiny hole being caused in the tyre, the same can be repaired simply by plugging, whereas in case of the conventional tyres it takes quite some time to remove the tube for repair. Apart from this, a tubeless tyre retains the air pressure for longer period even when punctured by nail provided the same is held in place.

Carcass Types

Carcass or skeleton of the tyre is of 3 types

1 Cross ply or bias ply
2 Radial Ply
3 Belted bias type

The tyre is named after the particular type of carcass it contains as this is the main structure taking the stresses while in operation.

Cross Ply type

In this type, the ply cords are woven at an angle (30deg - 40deg) to the tyre axis. There are two layers which run in opposite directions. However, the cords are not woven like wrap and weft of ordinary cloth because that would lead to rubbing of the two layers and thus produce heat which would damage the tyre material (fig 1).

Radial ply type

In this ply cords run in the radial direction i.e. in the direction of the tyre axis. Over this basic structure, run a number of breaker strips in the circumferential direction. The material for the breaker strips must be flexible but inextensible, so that no change of circumference takes place with change of the amount of inflation. Without the breaker strips, radial plies would give very soft ride, but there will not be any lateral stability. The extensible breaker strip behaves like a girder in its own plane and provides the directional stability (fig 2).

EXPERIMENT NO. 4

AIM : To study and prepare report on the constructional details, working principles and operation of the following Automotive Steering Systems:

a) Manual Steering systems e.g. Pitman Arm Steering, Rack & Pinion Steering
b) Power Steering Systems e.g. Rack and Pinion Power Steering System

Purpose of Steering System

The steering system allows the driver to guide the vehicle along the road and turn left or right as desired. The system includes the steering wheel, which controls the steering gear. It changes the rotary motion of the wheel into straight line motion. Manual systems were popular but now power steering has become popular. It is now installed on about 90% of the vehicles being manufactured.

Types of Steering Systems

Figure shows a simplified pitman-arm type of steering system. The rack-and-pinion type is shown in fig. describes how the wheels are supported on steering knuckles. The steering knuckles are attached to the steering arms by ball joints. The bal joints at each wheel permit the steering knuckle to swing from side to side. This movement turns the front wheels left or right so that the car can be steered.

The recirculating ball steering gear is shown in fig. In these units, the worm gear on the end of the steering shaft has a special nut, running on it. The nut rides on rows of small recirculating balls. The recirculation balls move freely through grooves in the worm and inside the nut. As the steering shaft is rotated, the balls force the nut to move up and down the worm gear. A short rack of gear teeth on one side of the nut mesh with the sector gear. Therefore, as the nut moves up and down the worm , the sector gear turns in on direction or the other for steering.

The recirculating balls are the only contacts between the worm and the nut. This greatly reduces friction and the turning effort or force applied by the driver for steering.

The balls are called recirculating balls because they continuously recirculate from one end of the ball nut to the other end through a pair of ball return guides. For example, suppose the driver makes a right turn, then the worm gear rotated in a clockwise direction when viewed from the drivers seat. This causes the ball nut to move upward. The ball roll between the worm and the ball nut. As the balls reach the upper end of the nut, they enter the return guide and the roll back to the lower end. There they reenter the groove between the worm and the ball nut.

Rack and pinion steering gears

The rack and pinion steering gear has become increasing popular for today's smaller cars. It is simpler, more dire acting and may be straight mechanical or power assisted operation. Figure shows a complete rack and pinion…

Rack and Pinion Power Steering

A power rack and pinion steering gear is another design of integral power steering The rack functions as the power piston. The tie rods are attached between the rack and the spindle steering arms. The control valve is connected to the pinion gear

Operation of the control valve is similar to that for the integral power steering gear When the steering wheel is turned, the resistance of wheels and the weight of vehicle cause the torsion bar to twist. This twisting causes rotary valve to move in its sleeve, aligning the fluid passages for the left, right, or neutral position. Oil pressure exerts force on the piston and helps move the rack to assist the turning effort. The piston is attached directly to the rack. The housing tube functions as the power cylinder.

The gear assembly is always filled with fluid, and all internal components are immersed in fluid. This makes periodic lubrication unnecessary, and also acts as a cushion to help absorb road shocks. On some rack and pinion power steering gears al fluid passages are internal except for the pressure and return hoses between the gear and pump.

Steering Linkages

Steering linkage depends upon the type of the vehicle, whether it is a car which has independent front suspension or a commercial vehicle having generally a rigid axle type front suspension. Each of these linkages will now be described.

Steering linkage for vehicle with rigid axle front suspension.

The drop arm (also called pitman arm) is rigidly connected to the cross shaft of the steering gear at its upper end, while its lower end is connected to the link rod through a ball joint. To the other end of the link rod is connected the link rod arm through a ball joint. Attached rigidly to the other end of the link rod arm is the stub axle on which the road wheel is mounted. Each stub axle has a forge track rod arm rigidly bolted to the wheel axis. The other ends of the track rod arms are connected to the track rod by means of ball joints. The design of these ball joints is such that the expanding spring compensates for wear or mis-adjustments. An adjuster is also provided in the track rod to change its length for adjusting wheel alignment. The steering gear provides mechanical advantage so that only a small effort is required at the steering wheel to apply a much larger force to the steering linkage. Moreover it also provides the desired velocity ratio so that much smaller movement of the stub axle is obtained with large angular movement of the steering wheel. When the steering wheel is turned, the swinging action of the drop arm imparts a near linear movement to the link rod. This movement is transmitted through the link rod arm to the stub axle so as to turn the later about its pivot, which may be a king pin or ball joints. The other wheel is steered through the track rod. Thus only one wheel is positively steered.

Rack and pinion steering gear

This type of steering gear is used on light vehicles like cars and in power steering. Maruti 800 cars employ this steering gear. It is simple, light and responsive. It occupies very small space and uses lesser number of linkage components compared to the worm and wheel type of gear.

Larger amount of torque is required to be applied by the driver for steering of medium and heavy vehicles. The power steering system provides automatic hydraulic assistance to the turning effort applied to the manual steering system. The power system is designed to become operative when the effort at wheel exceeds a predetermined value, say 10N. the system is always so designed that in the event of the failure of the power system, the driver is able to steer the vehicle manually although with increased effort.

The power steering systems are operated by fluid under pressure. The fluids usually used are oils of viscosity rating SAE 5 W or SAE 10 W or higher depending upon atmospheric conditions. The systems operate under fairly high pressures which may be as much as 7 MPa.

The principle of working of all the power steering systems is same. The slight movement of the steering wheel actuates a valve so that the fluid under pressure from the reservoir enters on the appropriate side of a cylinder, thereby applying pressure on the side of a piston to operate the steering linkage, which steers the wheel in the appropriate direction.

When the driver applies a force on the steering wheel to steer, the far end of the torsion bar, being connected to the spool of the rotary valve and the worm offers resistance. When the force at the wheel exceeds a predetermined value, the spool turns through a small angle, when the return line is closed and the fluid under pressure goes to one side of the rack piston and moves it to effect steering in the desired direction. The torsion bar is meant to give a feel of the steering to the driver. The rotation of the steering wheel in the opposite direction connects the other side of the steering gear to the pressure line. In the neutral steer position both sides of the piston (nut) are shut off to the pressure line and so they are at the same pressure but the return line is open due to which the fluid goes on circulating through the valve without causing any steering effect.

EXPERIMENT NO. 5

AIM : To study and prepare repot on the constructional details, working principles and operation of Automotive Brake Systems.

a) Hydraulic and Pneumatic Brake Systems
b) Drum Brake System
c) Disc Brake System

T h e o r y

Labelled Diagram, Constructional Details, Working Principle and Operation of the above Steering Systems

P R I N C I P L E

It goes without saying that brakes are one of the most important control components of vehicle. They are required to stop the vehicle within the smallest possible distance and this is done by converting the kinetic energy of the vehicle into the heat energy which is dissipated into the atmosphere.

B R A K I N G R E Q U I R E M E N T S

1 The brakes must be strong enough to stop the vehicle within a minimum distance in an emergency. But this should also be consistent with safety. The driver must have proper control over the vehicle during emergency braking and the vehicle must not skid.

2 The brakes must have good antifade characteristics i.e. their effectiveness should not decrease with constant prolonged application e.g. while descending hills. This requirement demands that the cooling of the brakes should be very efficient.

H Y D R A U L I C B R A K E S

Most of the cars today use hydraulically operated foot brakes on all the four wheels with an additional hand brake mechanically operated on the rear wheels. An outline of the hydraulic braking system is shown in fig. the main component in this is the master cylinder which contains reservoir for the brake fluid. Master cylinder is operated by the brake pedal and is further connected to the wheel cylinders in each wheel through steel pipe lines, unions and flexible hoses. In case of Hindustan Ambassador car, on front wheels each brake shoe is operated by separate wheel cylinder (thus making the brake two shoe leading) whereas in case of rear wheels there is only one cylinder on each wheel which operates both the shoes (thus giving one leading and one training shoe brakes.) As the rear wheel cylinders are also operated mechanically with the hand brake, they are made floating. Further, all the shoes in the Ambassador car are of the floating anchor type.

The system is so designed that even when the brakes are in the released position, a small pressure of about 50 kPa is maintained in the pipe lines to ensure that the cups of the wheel cylinder are kept expanded. This prevents the air from entering the wheel cylinders when the brakes are released. Besides, this pressure also serves the following purposes.

1.It keeps the free travel of the pedal minimum by opposing the brake shoe retraction springs.
2.During bleeding, it does not allow the fluid pumped into the line to return, thus quickly purging air from the system

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D R U M B R A K E S

In this type of brakes, a brake drum is attached concentric to the axle hub whereas on the axle casing is mounted a back plate. In case of front axle, the back plate is bolted to the steering knuckle. The back plate is made of pressed steel sheet and is ribed to increase rigidity and to provide support for the expander, anchor and brake shoes. It also protects the drum and shoe assembly from mud and dust. Moreover, it absorbs the complete torque reaction of the shoes due to which reason it is sometimes also called torque plate. Two brake shoes are anchored on the back plate as shown in fig. Friction linings are mounted on the brake shoes. One or two retractor springs are used which serve to keep the brake shoes away from the drum when the brakes are not applied. The brake shoes are anchored at one end, whereas on the other ends force F is applied by means of some brake actuating mechanism which forces the brake shoe against the revolving drum, thereby applying the brakes. An adjuster is also provided to compensate for wear of friction lining with use. The relative braking torque obtained at the shoes for the same force applied at the pedal varies depending upon whether the expander (cam or toggle lever) is fixed to the back plate or it is floating, whether the anchor is fixed or floating and whether the shoes are leading or trailing.

D I S C B R A K E S

As shown in fig. a disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle, like the axle casing or the sub axle and is cast in two parts, each part containing a piston. In between each piston and disc, there is friction pad held in position by retaining pins, spring plates etc. Passages are drilled in the caliper for the fluid to enter or leave each housing. These passages are also connected to another one for bleeding. Each cylinder and contains a rubber sealing ring between the cylinder and the piston.

When the brakes are applied, hydraulically actuated pistons move the friction pads into contact with the disc, applying equal and opposite forces on the later. On releasing the brakes, the rubber sealing rings act as return springs and retract the pistons and the friction pads away from the disc.

For a brake of this type
$T = 2\mu paR$
Where
μ= coefficient of friction
p= fluid pressure
a= cross sectional area of one piston
R = distance of the longitudinal axis of the piston from the wheel axis

B R A K E S Y S T E M F O R M A R U T I (S U Z U K I) 8 0 0 C A R

The front wheel brakes are of the disc type, whereas for rear wheels drum type brakes (leading trailing shoes) are employed. Parking brake is mechanically operated by a wire and link system and works on the rear wheels only. Same brake shoes are used for service and parking brakes. The layout of the system is shown in fig.

A tandem master cylinder is employed. The hydraulic pressure produced there is applied to two independent circuits. One circuit is for front left and rear right brakes, whereas the other is for front right and rear left brakes. Due to this reason, the braking system in the Maruti has greater safety because even if a pressure leak occurs in the brake line of one circuit, the other braking circuit works, due to which a certain degree of braking is still available to the vehicle.

EXPERIMENT NO. 6

AIM : To study and prepare report on the construction details, working principles and operation of the following automotive suspension systems.

a) Front suspension system
b) Rear suspension system

Theory

Labeled diagram, construction details, working principle and operation of the following suspension systems

a) Front suspension system
   - i) Double Wishbone Suspension
   - ii) Macpherson Strut Front Suspension

b) Rear suspension system
   - i) Leaf Spring Rear Suspension
   - ii) Coil Spring Rear Suspension
   - iii) Macpherson Strut Rear Suspension

Objects of Suspension

1 To prevent the road shocks from being transmitted to the vehicle components
2 To safeguard the occupants from road shocks
3 To preserve the stability of the vehicle in pitching or rolling, while in motion

Leaf Springs

Semi elliptic leaf springs are almost universally use for suspension in light and heavy commercial vehicles. For cars also, these are widely used for rear suspension.

Tapered Leaf Springs

English Steel Corporation Ltd. Of England has produced 'Taperlite' springs which have the following advantages over the conventional leaf springs due to which these are becoming increasingly popular compared to constant section conventional leaf springs.

1. Light weight - nearly 60% of the corresponding conventional spring

2. There is no interleaf friction in case of single taper leaf spring. Even in case of heavy vehicles where more leaves may be required, the number of such leaves is still less than in case of conventional springs. Further, these rub against each other only at the ends. Due to these reasons even in multi taper leaf springs relatively less inter leaf friction will be present.

3 Absence of squeaking

4. The stresses are lower and more uniform compared to the conventional springs, thus giving longer life.

5. They occupy less space.

6. In case of single taper leaf spring, there is no collection of moisture between the leaves and hence no fretting fatigue.

Coil Springs

The coil springs are used mainly with independent suspension, though they have also been used in the conventional rigid axle suspension as they can be well accommodated in restricted spaces. The energy stored per unit volume is almost double in the case of coil springs than the leaf springs.

Coil springs do not have noise problems nor do they have static friction causing harshness of ride as in case of leaf springs.

The spring takes the shear as well as bending stresses. The coil springs, however, cannot take torque reaction and side thrust, for which alternative arrangements have to be provided.

A helper coil spring is also sometimes used to provide progressive stiffness against increasing load.

Shock Absorbers

A springing device must be a compromise between flexibility and stiffness. If it is more rigid, it will not absorb road shocks efficiently and if it is more flexible, it will continue to vibrate even after the bump has passed. So we must have sufficient damping of the spring to prevent excessive flexing.

The friction between the leaves of a leaf spring provides this damping, but because of the uncertainly of the lubrication conditions, the amount of friction also varies and hence the damping characteristics do not remain constant. For this reason, the friction between the springs is reduced to minimum and additional damping is provided by means of devices called dampers or shock absorbers. In case of coil springs, the whole of damping is provided by the shock absorbers. The shock absorbers thus control the excessive spring vibrations.

In fact the name shock absorber is rather misleading since it is the spring and not the shock absorber that initially absorbes the shock. The shock absorber absorbs the energy of shock converted into vertical movement of the axle by providing damping and dissipating the same into heat. Thus, it merely serves to control the amplitude and frequency of spring vibrations. It can not support weight and has zero resilience. Therefore, 'damper' is a better term technically to describe the shock absorber.

The shock absorbers are basically of two types - the friction type and the hydraulic type. The friction type has almost become obsolete due to its non predictable damping characteristics. The principle of operation of a hydraulic shock absorber is that when a piston forces the fluid in a cylinder to pass through some hole a high resistance to the movement of piston is developed, which provides the damping effect. The hydraulic type has the additional advantage that the damping is proportional to the square of the speed. So for small vibrations, the damping is also small, while for larger ones the damping becomes automatically more.

Wishbone type suspension

The use of coil springs in the front axle suspension of cars is now almost universal.

It consists of upper and the lower wishbone arms pivoted to the frame member. The spring is placed in between the lower wishbone and the underside of the cross member. The vehicle weight is transmitted from the body and the cross member to the coil spring through which it goes to the lower wishbone member. A shock absorber is placed inside the coil spring and is attached to the cross member and to lower wishbone member.

The wishbone arms are like the chicken wishbone or letter V in shapem because of which the system is so called. Because of this V shape, the wishbones not only position the wheels and transmit the vehicle load to the springs but these also resist acceleration, braking and cornering (side) forces. The upper arms are shorter arms are shorter in length than the lower ones. This helps to keep the wheel track constant, thereby avoiding the tyre scrub thus minimizing tyre wear. However, small change in the camber angle does occur with such an arrangement.

The wishbone type is the most popular independent suspension system.

Mac Pherson Strut type of suspension

In this layout only lower wishbones are used. A strut containing shock absorber and the spring carries also the stub axle on which the wheel is mounted. The wishbone is hinged to the cross member and positions the wheel as well as resists accelerating, braking and side forces. This system is simpler than double wishbone type described above and is also lighter, keeping the unsprung wieht lower. Further, the camber also does not change when the wheel moves up and down. This type of suspension gives the maximum room in the engine compartment and is therefore commonly used on front wheel drive cars.

In India this system has been used in Maruti (Suzuki) 800 cars. This type of suspension with anti roll bar as employed in Volkswagen Jetta and Passat cars is shown in fig. this is claimed t provide increased road safety, improve ride comfort and light and self stabilizing steering which means that car continues along its chosen line of travel when the brakes are applied even though the road surface may vary.

Rear Wheel Independent Suspension

Though the rear wheels are not to be steered, yet there is a considerable difficulty in the rear wheel springing if the power has to be transmitted to the rear wheels. But even the rear wheel independent springing is coming into prominence because of its distinct advantages over the rigid axle type.

Fig shows one method of rear wheel independent suspension. Universal couplings A and B keep the wheel vertical, while the sliding coupling C is required to maintain the wheel track constant, thereby avoiding scrubbing of the tyres. This method has been used in the de Dion type of axle.

EXPERIMENT NO.7

AIM : To study and prepare report on the construction details, working principles and operation of the following automotive drive lines and differential.

a) Rear wheel drive lines
b) Front wheel drive lines
c) Differentials, drive axles and four wheel drive lines

Theory

Labeled diagram, construction details, working principle and operation of the following drive lines and differential.

PROPELLER SHAFT

This is the shaft which transmits the drive from the transmission to the bevel pinion or worm of final drive in front engine, rear drive vehicles. It is also called drive shaft. It consists mainly of three parts.

(a) Shaft - As this has to withstand mainly torsional loads, it is usually made of tubular cross section. It also has to be well balanced to avoid whirling at high speeds.

(b) One or two universal joints, depending upon the type of rear axle drive used/ the universal joints account for the up and down movements of the rear axle when the vehicle is running

(c) Slip Joint - Depending upon the type of drive, one slip joint may be there in shaft. This serves to adjust the length of the propeller shaft when demanded by the rear axle movements.

Universal Joints

A universal joint is a particular type of connection between two shafts whose axes are inclined to each other. The most simple type of universal joint is the Hooke's joint which is most widely used because of the fact that it is simple and compact in construction and reasonably efficient at small angles of propeller shaft movement up and downm say upto 18 deg The axes of shafts A and B are intersecting. Each of these shafts contains a yoke. The cross C has four arms. The two opposite arms of the cross are supported in bushes in the yoke of shaft B. Thus shaft A can have angular rotation about axis XX and the shaft B, about the axis YY. It is thus seen that it will be possible with the Hookes joint for the shafts A and B to have positive drive while allowing angular movement between them.

An improved form of hooke's joint uses needle roller bearing to support the cross in the yokes. This result in increase of joint efficiency.

DIFFERENTIAL

When the car is taking a turn, the outer wheels will have to travel greater distance as compared to the inner wheels in the same time (fig) if therefore, the car has a solid rear axle only and no other device, there will be tendency for the wheels to skid. Hence if the wheel skidding is to be avoided, some mechanism must be incorporated in the rear axle, which should reduce the speed of the inner wheels and increase the speed f the outer wheels when taking turns; it should at the same time keep the speeds of all the wheels same when going straight ahead. Such a device which serves the above function is called a differential.

In case of the non-driving wheels, however, the difference in speeds of the inner and the outer wheels poses no problem since such wheels are independent of each other and as such they can adjust their speeds according to the requirements.

To the crown wheel of the final drive is attached a cage, which carries a cross pin (in case two planet pinions are employed) or a spider (in case four planet pinions are used in the differential). Two sun gears mesh with the two or four planet pinions. Axle half shafts are splined to each of these sun gears. The crown wheel is free to rotate on the half shaft as shown. When the vehicle is going straight the cage and the inner gears rotate as a single unit and the two half shafts revolve at the same speed. In this situation, there is no relative movement among the various differential gears. To understand what happens when the vehicle is taking a turn, assume that the cage is stationary. Then turn one sun gear will cause the other to rotate in the opposite direction. That means that if left sun gear rotates, n times in a particular time, the right sun gear will also rotate n times in the same period but of course in the opposite direction. This rotation is super imposed on the normal wheel speed when the vehicle is taking a turn. Thus, for example, consider a vehicle with wheel speed N r.p.m. going straight, when it takes a turn toward right. At this time, there will be a resistance to the motion of the right wheel and as a result of differential action if the right wheel rotates back at n rpm then the left wheel will rotate forward at n rpm. This will give the resultant speed of the left wheel as (N + n) and that of the right wheel as (N-n) rpm.

The torque from the final drive is also divided between the two half shafts. As the planet pinions are free to rotate on the cross pin or the spider arm they cannot apply different torque to the teeth on one side from the one on the other side. Therefore, they act as a balance and divide the torque equally between the two wheels on the axle, even when their speeds are different.

EXPERIMENT NO. 8

A I M : To study and prepare report on the construction details, working principles and operation of the automotive emission / pollution control systems.

T h e o r y

Labeled diagram, construction details, working principle and operation of the automotive emission / pollution control systems

I n t r o d u c t i o n

There are four areas in the automobile, which can emit pollutants into the atmosphere. These are, the fuel tank, carburetor, the crank case and the exhaust system. The fuel tank and the carburetor emit fuel vapours, the crankcase gives out the partly burnt-air-fuel mixture blown off through the piston rings, while the emissions from the exhaust system include unburnt hydrocarbons, carbon monoxide, nitrogen oxides and sulphur oxides. These exhaust constituents cause many serious diseases as given below. Obviously, the atmospheric pollution can be decreased by controlling these areas of the automobile. To do this, two different approaches have been followed:

1 To reduce the formation of pollutants in the emissions by redesigning the engine ventilating system, carburetor and fuel tank. The combustion chamber, alongwith fuel system cooling system, ignition system and the exhaust system are also redesigned thus improving upon the combustion efficiency which reduces the emissions.

3.To destroy the pollutants after these have been formed. The details of both these approaches have been discussed in the following articles.

S. No.	Constitutent	Disease
1	Carbon Monoxide (CO)	Heart/Blood circulatory problems
2	Hydrocarbons (HC)	Lung diseases
3	Nitrogen oxides (NOx)	Asthma / Bronchitis
4	Lead (Pb)	Blood Cancer
5	Suspended particulate matter (PM)	Asthma / Bronchitis

R E D U C T I O N O F F O R M A T I O N O F P O L L U T A N T S

This is achieved by the following:

1. Closed crankcase ventilation
2. Fuel tank and carburetor ventilation
3. Redesigning the engine:

i) combustion chamber
ii) cooling system
iii) fuel supply system
iv) ignition system

C L O S E D C R A N C K C A S E V E N T I L A T I O N

There are two variations of this system viz. the positive crankcase ventilation and the fixed orifice system. In the former, filtered air from the carburetor air cleaner is introduced in the crankcase from where it carries away the blow by gases and the gasoline vapours enter the engine combustion chamber alongwith fresh charge and are burnt there.

In the fixed orifice system, a fixed orifice in the base of the carburetor takes the place of the PCV valve. The blow by gases are diverted to the inlet manifold through this orifice.

In both these types of closed crankcase ventilation systems, the sludge and the other similar elements during the course of time, clog the PCV valve or the orifice which may decrease and ultimately stop the flow of the blow by gases altogether, which would affect the engine performance very seriously. A coating of oil on the air cleaner filter, apart from various engine troubles, indicates that service of the system is needed urgently, which mainly requires the cleaning of the PCV valve or the orifice, the air cleaner filter hoses etc.

R E D E S I G N I N G T H E C O M B U S T I O N C H A M B E R

To avoid the addition of lead is gasoline, the engine combustion chambers have been redesigned with lower compression ratios (from approximately 10.5 : 1 to 8.5 : 1) This loss of efficiency has been made good by increasing the temperature in the combustion chamber which results in improved combustion of the air fuel mixture and consequently in the decrease of pollutants in the exhaust.

C H A N G E S I N F U E L S U P P L Y S Y S T E M

Suitable modifications have been made in the intake manifolds so that rapid vaporization of fuel takes place during warm up of the engine. Further, cross over of the inlet and the exhaust manifolds is also redesigned so as to reduce the time required for the transfer of heat from the exhaust gases to the inlet gases. Moreover, in case of engines with petrol injection in particular, a tuned intake manifold is employed, wherein all runners are of equal length with very little restriction so that equal air flow takes place to all the cylinders. This combination of petrol injection and tuned intake manifold helps reduce emission of HC and NOx.

Apart from increasing the valve overlap discussed above, a better method of diluting the intake charge of the engine with exhaust gas is the exhaust gas recirculation (EGR) system, which reduces NOx emission. Due to absence of oxygen, exhaust gas itself will not burn; it only lowers the combustion temperature thereby reducing the formation of NOx The amount of exhaust gas admitted is regulated by a vacuum controlled valve, called the EGR valve.

The exhaust gases from the engine are passed through catalytic converters. A catalytic converter is a cylindrical unit about the size of a small silencer and is installed into the exhaust system of a vehicle such as a car, scooter, moped, motor cycle or auto rickshaw. It is placed between the exhaust manifold and the silencer. Inside the converter there is a honeycomb structure of a ceramic or metal, which is coated with alumina base materials and thereafter a second coating of precious metals platinum, palladium or rhodium or combinations of the same. This second coating serves as a catalyst. A catalyst is a substance which causes a chemical reaction that normally does not happen in the given condition. As a result of catalytic reactions, as the exhaust gases pass over the converter subtrate, toxic gases such as CO, HC and NOx are converted into harmless CO2 H2 and N2.

There are two types of catalytic converters.

1. A two way converter, which is used to control only CO and HC emissions by oxidation.

2. A three way converter, which is used almost in all cars. It controls CO and HC by oxidation as well as NOx by reduction.

Three way converters (TWC) are now commonly being used for petrol engines and operate in two stages. The first converter stage uses rhodium to reduce the NOx in the exhaust into nitrogen and oxygen. In the second stage, converter platinum or palla dium acts as oxidation catalyst to change HC and CO into harmless water and
CO2.

EXPERIMENT NO. 9

AIM : To study and prepare report on the constructional details, working principles and operation of the following fuel supply systems

a) Carburetor
b) Diesel fuel injection system
c) Gasoline fuel injection system

Theory

Labeled diagram, construction details, working principle and operation of the fuel supply systems

Functions of a carburetor

The main functions which a carburetor is required to perform are

1 To keep a small reserve of fuel at a constant head
2 To vaporize the fuel to prepare a homogeneous air fuel mixture
3 To supply correct amount or the air fuel mixture at the correct strength under all conditions of load and speed of the engine

Simple carburetor

To understand the principle on which a carburetor works, consider a simple carburetor as shown in fig. The main parts are a float chamber, fuel jet, venturi, nozzle and a throttle valve. The float in the float chamber is made of deep drawn brass sheet and is kept hollow for lightness. Such floats have a tendency to leak along the joint seams. Due to this reason floats are now made of nylon plastic or expanded synthetic rubber. The needle valve attached to the float lever serves to close or open the fuel inlet to the float chamber depending upon the requirements. The needle valve consists of a cylindrical stem with a conical tip made of steel or else a solid steel stem with a rubber seat tip. Alternatively, there may be a three piece valve with a rubber seat tip and a spring - loaded ball in the body of the stem. The later two types maintain the liquid - tight seal during vibrations, which is not possible with ordinary single piece needle valve. When the fuel level falls below a definite predetermined value, the float also falls along with fuel level, thus opening the passage for the fuel supply. The fuel starts flowing in and the float rises gradually till the fuel level reaches the desired value. At this time, the float needle closes the fuel inlet passage. Thus a constant head of fuel is maintained in the float chamber. This constant level of fuel is slightly below the nozzle outlet, so that the fuel may not drop all the time from the nozzle, even when the engine is not working. This provision also prevents the fuel from spilling out when the car is tilted on account of hilly or highly cambered road. In practice fuel level in the float chamber is maintained about 5mm below the nozzle outlet. A small vent in the float chamber keeps the pressure inside atmospheric. In modern practice it is preferred to vent the float chamber to the air intake of the carburetor. Such an arrangement prevents dust particles from mixing with the petrol through the vent as there is always an air cleaner on the intake side of the carburetor which filters the incoming air.

Fuel Injection System

The function of a fuel injection system is to inject proper quantity of fuel into the engine cylinders at the correct time and at a predetermined rate. The fuel injection systems may be broadly classified into the solid injection

system and the air injection system. In the solid injection system, only the liquid fuel is injected, whereas in the injection system liquid fuel is injected along with compressed air. The air injection system is less reliable, less efficient and requires an air compressor for supplying air at 7 Mpa or higher pressures (which consumes upto 10% of the power output of the engine) due to which reasons it has become obsolete. The solid injection system will, therefore, be discussed here in detail.

Two types of solid injection systems are in use:
1. common rail fuel injection system
2. individual pump fuel injection system

Layout of a common rail fuel injection system is shown in fig. This type of fuel supply system is used in the Detroit diesel engine, commonly known as Jimmy diesel. In this a single injection pump with injector, called as unit injector is employed on each cylinder. The unit injectors are operated by rocker arms and springs similar to the engine valves. A linkage connects the control racks of all the unit injectors, so that fuel injection in all the cylinders may be equal and simultaneously controlled.

The fuel is taken from the fuel tank by the feed pump and is supplied at low pressure through a filter, to all the unit injectors. This avoids the high pressure fuel lines necessary in the individual pump system. Any excess fuel from the relief valve is returned to the fuel tank.

Individual pump fuel injection system using in line injection pump is shown in fig. Fuel is drawn from the fuel tank by means of a fuel feed pump which is operated from the injection pump camshaft. Generally, the plunger type or the diaphragm type of fuel feed pumps are employed in automobiles. The pump is provided with hand priming lever so that the diesel oil can be forced into the system and the air bled out without turning the engine. The fuel is then passed through a filter and thence to the fuel injection pump. Without the filter or with a poor quality filter, abrasive matter would reach the fuel injection pump and injectors, resulting in poor starting, irregular idling and deterioration in performance due to decreased fuel delivery from the injection pump. The abrasive matter would also cause faulty spraying and leakage in the injectors thus resulting in increased fuel consumption and heavy exhaust smoke.

EXPERIMENT NO. 10

Aim

To study and prepare report on the constructional details working principles and operation of the following automotive engine systems and sub systems

a) Multi cylinder; diesel and petrol engines
b) Engine cooling and lubricating system

Theory

Labeled diagram, construction details, working principle and operation of the engine systems and sub systems

Methods of cooling

Various methods used for cooling of automobile engines are

1 Air cooling
2 Water cooling

Air cooling

The basic principle involved in this method is to have current of air flowing continuously over the heated metal surface from where the heat is to be removed. The heat dissipated depends upon following factors;

a) Surface area of metal into contact with air
b) Mass flow rate of air
c) Temperature difference between the heated surface and air
d) Conductivity of metal

Advantages

1 Air cooled engines are lighter because of the absence of the radiator, the cooling jackets and the coolant
2 They can be operated in extreme climates where the water may freeze.
3 In certain areas where there is scarcity of cooling water, the air cooled engine is an advantage.
4 Maintenance is easier because the problem of leakage is not there.
5 Air cooled engines get warmed up earlier than the water cooled engine

Disadvantages

1 It is not easy to maintain even cooling all around the cylinder, so that the distortion of the cylinders take place. This defect has been remedied sometimes by using fins parallel to the cylinder axis. This is also helpful where a number of cylinders in a row are to be cooled. However, this increases the overall engine length.

2 As the coefficient of heat transfer for air is less than that for water, there is less efficient cooling in this case and as a result the highest useful compression ratio is lesser in the case of air cooled engines than in the water cooled ones.

3 The fan used is very bulky and absorbs a considerable portion of the engine power (about 5%) to drive it.

4 Air cooled engines are more noisy, because of the absence of cooling water which acts as sound insulator.

5 Some engine components may become inaccessible easily due to the guiding baffles and cooling which makes the maintenance difficult.

Water cooling

In water cooling system, the cooling medium used is water. In this, the engine cylinders are surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into water which goes to the radiator where it loses its heat to the air. Usually some antifreeze is added to the cooling water, due to which it is often referred to as coolant. Both these terms have been used in this chapter, often meaning same unless the context requires otherwise.

Water cooling systems are of two types;
1 Thermosyphon system
2 Pump circulation system

Advantages

1 As the circulation of coolant is maintained by natural convention only, the cooling is rather slow. Therefore, to have adequate cooling, the capacity of the system has to be large.

2 Due to the quantity of coolant being large, it takes, more time for the engine to reach the operating temperature.

3 Radiator header tank must be located higher than the top of the cylinder coolant jackets, which is no more possible with the modern body styles.

4 Certain minimum level of coolant water must be maintained in the system. If the coolant falls below that level, continuity of flow would break and the system would consequently fail.

Systems of engine lubrication

The various systems adopted for the lubrication of automobile engine are

1 Petroil system

Splash system

2 Pressure system
3 Dry sump system

Petrol system

This is used generally for small two stroke engines, e.g. in majority of scooter and motor cycle engines. It is the simplest of all types of engine lubrication systems. Certain amount of the lubricating oil is mixed with the petrol itself, the usual ratio being 2% to 3% of oil. If it is less, there is danger of oil starvation or insufficient lubrication causing damage to the engine; if however, it is more, there will be excessive carbon deposits in the cylinder head and the engine will also give dark smoke.

When the petrol mixture enters the crankcase, due to high temperatures there, the petrol component vaporizes leaving a thin film of lubricating oil on the crankcase, cylinder walls, crankshaft and bearings.

The main requirements of lubricating oil for two stroke engine are that it should readily mix with petrol and burn without leaving much residue.

Splash system

This was employed for the engines of early motor cycles. It is one of the cheapest methods of engine lubrication. A scoop is made in the lowest part of the connecting rod and the oil is stored in the oil trough it being pumped there from the crankcase oil sump. When the engine runs the scoop causes the oil to splash on

the cylinder walls each time it passes through its BDC position. This affects the lubrication of engine walls, gudgeon pin, main crankshaft bearings, big end bearings etc.

Pressure system

This system is used almost universally in modern car engines. The splash system though cheaper, is not suitable for automobile engines because of the absence of positive lubrication. In the pressure system (fig) an oil pump takes the oil from the wet sump through a strainer and delivers it through a filter to the main oil gallery at a pressure of 200 to 400 kPa. The oil pressure is controlled by means of a pressure relief valve, situated in the filter unit or the pump housing.

Dry sump system

This system is employed in some racing car engines for situations where the vehicle has to be operated at very steep angles, for example, sports cars, jeeps etc. if ordinary pressure system of lubrication is used in such cases, the situations may arise when there is no oil at the place where oil pump is installed. To avoid such instances, dry sump system is used (fig)wherein two pumps, instead of one, are used. The scavenge pump A is installed in the crankcase portion which is the lowest. It pumps oil to a separate reservoir B, from where the pressure pump C pumps the oil through filter D, due to the cylinder bearings; a full pressure system of lubrication is employed. The oil pressure is maintained at 400-50 kPa for the main and big end bearings while about 5- - 100 kpa pressure is used for timing gears and cam shaft bearings etc.