Lecture -05
Construction of Reciprocating Engine

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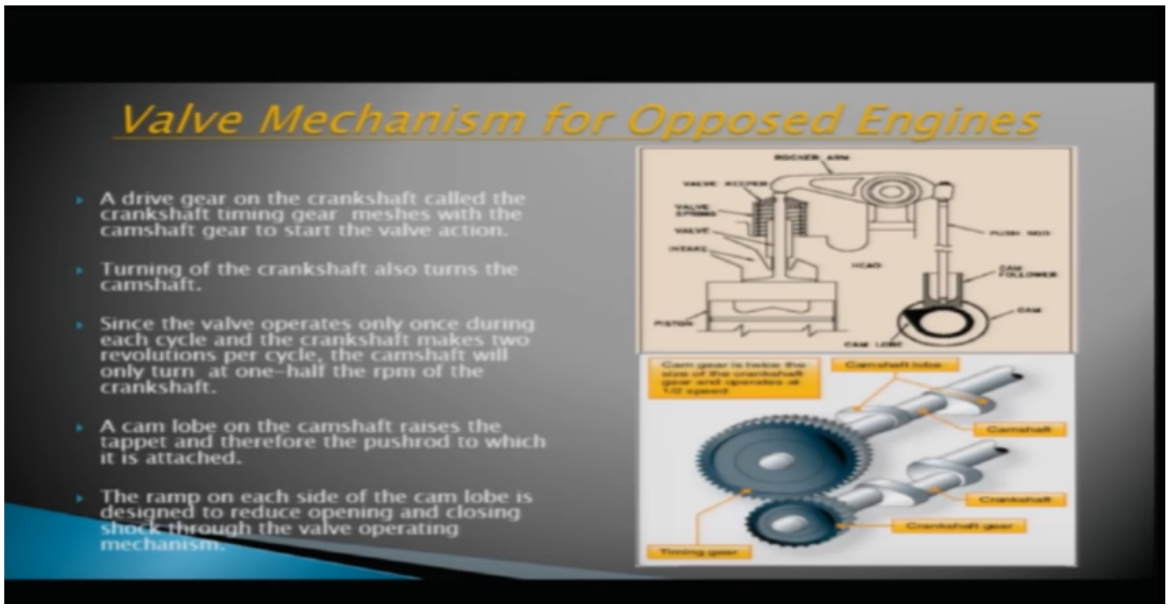

So, next is evolved mechanism for horizontally opposed engines. Here you can see two figures, the bottom figure, if you see, this is your crankshaft and this is your camshaft, there is a timing gear on both the shafts, this is your crankshaft timing gear and this is your, camshaft timing gear and this is your crankshaft timing gear. So, a drive gear on the crankshaft, this is your crankshaft a drive gear on the crankshaft, which is called a, 'Crankshaft Timing Gear', meshes with the camshaft gear, this is your camshaft, it meshes with the camshaft gear. So, the crankshaft timing gear, meshes with the camshaft timing gear, to start the valve action. Turning of the crankshaft also turns the camshaft. So, as the crankshaft is turned this shaft since the two gears are meshed this shaft camshaft will also turn, since the valve operates, only once during each cycle and the crankshaft makes two revolutions per cycle, we have studied earlier that a crankshaft makes two revolutions per cycle, and evolve operates only once during each cycle. The camshaft will only turn at 1/2 the RPM of the crankshaft. So, the camshaft is going to turn only 1/2 the RPM, of the crankshaft, a cam lobe on the camshaft, this is your camshaft, this is your cam lobe, so, a cam lobe on the camshaft raises the tappet and therefore the push rod to which it is attached, here in this figure, on the top you can see, this is your camshaft, the cam lobe, the cam lobe on the camshaft ,will raise the tappet, this is your tappet we also call it a Volvo lifter, this cam lobe pushes the valve lifter or the tappet and this in turn pushes the push rod, here is your push rod, this pushes the push rod to which it is attached. The ramp on each side of the cam lobe, this is your ramp, the ramp on each side of the cam lobe is designed to reduce opening and closing shock to the valve opening mechanism. So, the design of the cam lobe is such that, it reduces opening and closing shock, to the valve operating mechanism.

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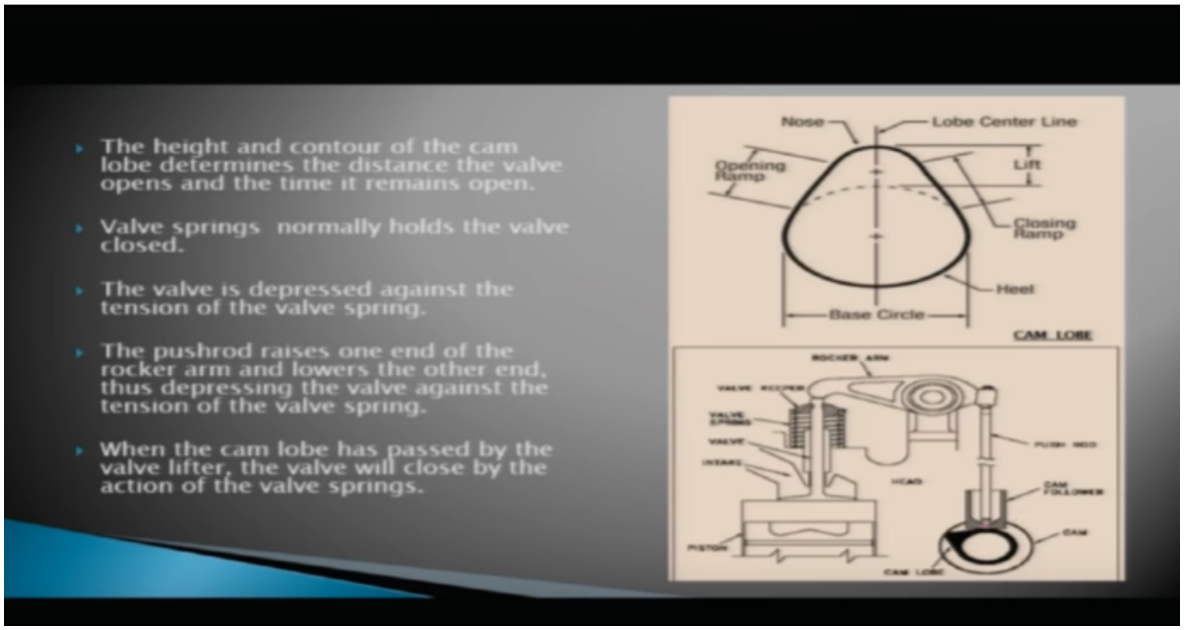

The height and contour of the cam lope you can see here the height and the contour of the cam lobe, determines the distance the valve opens and the time it remains open. So, the design of the cam lobe is very important that height and the contour of the can, this decides the distance the valve will open and the duration the time it remains open valve Springs normally hold the valve closed here in the diagram this is there is a schematic diagram here in the bottom you can see this is your cam shaft cam lope here is your hydraulic tappets or the valve lifter this, cam shaft, when it turns that it pushes your hydraulic tappet which in turn pushes the push rod, there is a rocker arm here, this push rod pushes the rocker arm, which this rocker arm, is hit at this point, when this side goes up, the other side goes down and the other side of the rocker arm pushes the valve this is the valve here you can see and these are your valve springs, this is your valve here and this valve is held by the valve Springs. So, in the valve operating mechanism you can see this is your cam shaft the cam lobes, the hydraulic tappets letters then you have the push rods, you have the rocker arm, then you have the valve this is the stem of the valve the tip of the valve, which are this valve is held by the valve Springs, the valve Springs these valve Springs normally hold the valve closed, the valve is depressed against the tension of the valve spring. So, in order to open the valve the valve is depressed against the tension of this valve spring the pushrod raises one end of the rocker arm this push rod here you can see the push rod this will raise one end of the rocker arm. So, when this push rod is pushed it will raise one end of the rocker arm this side will go up, and lowers the other end. So, this when this side goes up, this side will come down, thus depressing the valve this will depress the valve against the tension of the valve spring. So, this will depress the valve against the tension of the valve spring, when the cam lobe has passed by the valve lifter now when this cam lobe, this has passed by the valve lifter, the valve will close by the action of the valve springs. So,

when the valve since this cam shaft is continuously rotating, when this cam lobe has passed valve lifter, the valve with closed by the action of the valve.

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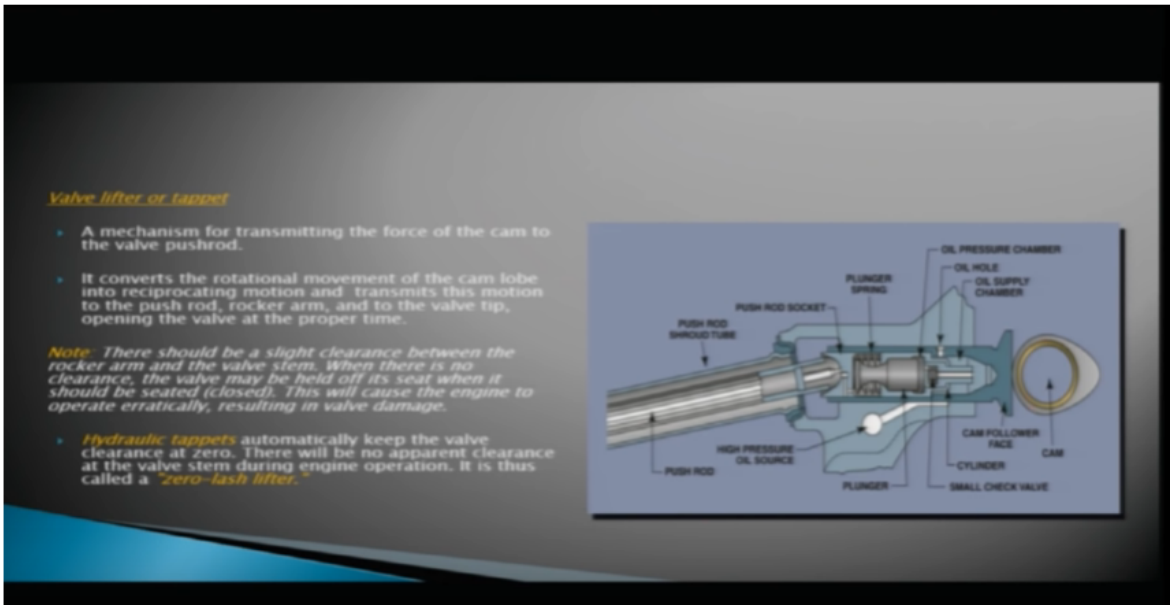

So, now we come to, valve lifter here in the diagram you can see there is a valve lifter this is your cam lobe, this is your valve lifter, this is your push rod and the internal mechanism of the valve lifter is shown here. What is a valve lifter we also call it a tap it? What is it actually? It is a mechanism for transmitting the force of the cam to the valve push rod. So, for transmitting the force of the cam lope, to the valve push rod, this mechanism is used this hydraulic this tappet or the world lifter is used; it converts the rotational motion of the cam lobe, the rotational motion of the cam lobe, into the reciprocating motion. So, this lifter this valve lifter, converts the rotational motion of the cam lobe to the reciprocating motion of the push rod and it transmits this motion to the push rod, rocker arm and to the valve tip opening the valve at the proper time.

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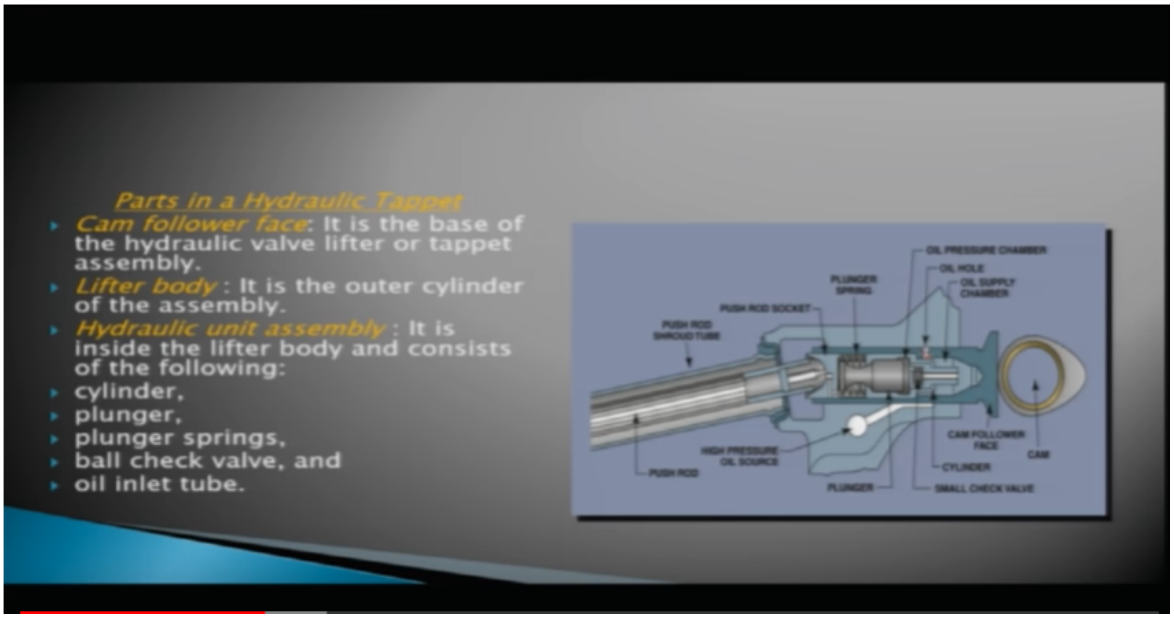

Now what are the parts in the hydraulic tappets? So, these valve lifters, they are also hydraulic, these days the hydraulic valve lifters are used they are also called, 'Zero Lash Mall Lifters', they maintain the clearance the valve clearance, to zero and what are the parts in a hydraulic tappet? first is the cam follower face this is your cam follower face here, it is the base of the hydraulic ball lifter or tap at assembly. So, this is the base of your lifter body, it is the outer cylinder of the assembly. So, this is your lifter body, this is the outer cylinder of the assembly, the hydraulic unit assembly it is inside the lifter body this hydraulic unit assembly it is inside the lift her body and consists of the following. Number one is cylinder, this is your cylinder here ,inside the lifter body, you can see this is your cylinder, then there is a plunger here this is your plunger, plunger Springs these are your plunge Springs here, the ball check valve this is your ball check ball here, you can see this is your ball check valve and the oil inlet tube, this is here this is an oil inlet tube, so, this is a small unit a hydraulic valve lifter, where you can see the cylinder, the plunger, plunger Springs and the ball check valve and the oil inlet hole.

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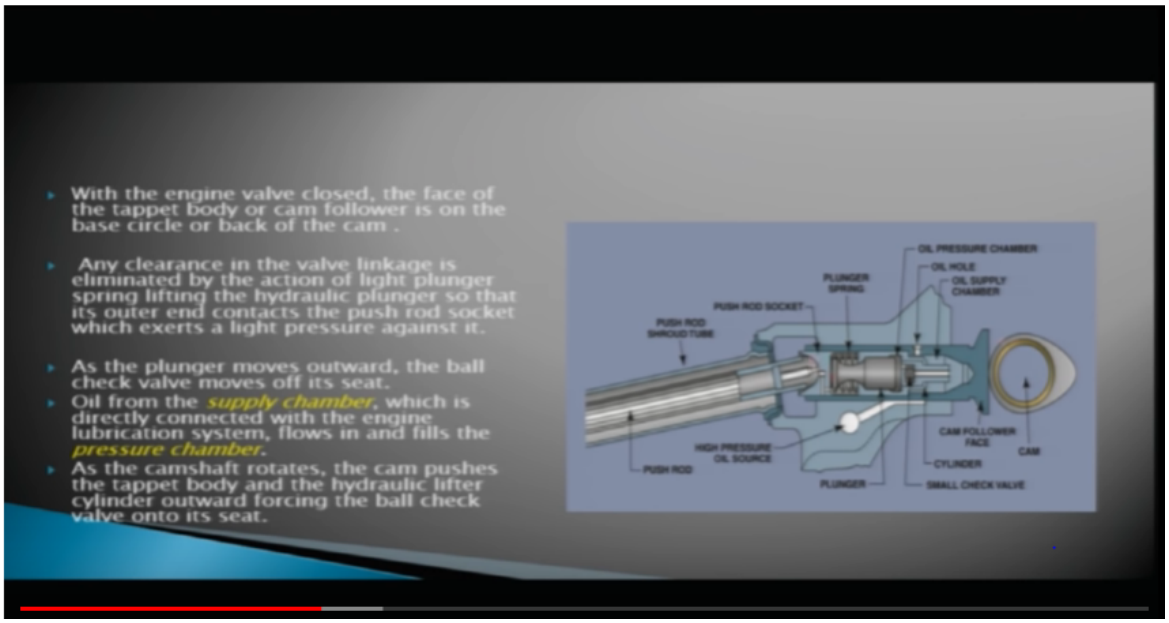

Now how does this valve lifter work, with the engine valve closed now when the engine valve is closed, the face of the tappet body or the cam follower is on the base circle or back of the cam. So, this is the back of your cam, the face of the, the tappet body is on the back of the cam or the base circle, any clearance in the valve linkage. So, any clearance in the valve linkage is eliminated by the action of light plunger spring. So, any clearance in the valve linkage this valve linkage is eliminated by, the action of this spring, which will lift the hydraulic plunger. So, if there is any clearance in the valve linkage, this spring will lift the hydraulic plunger. So, that its outer end, so, that its outer end contacts the pushrod socket this is your pushrod socket, this spring will push will pull this plunger and this outer side will touch the pushrod socket, which exerts a light pressure against it as the plunger moves outward, as the plunger as the Splendor moves outward, the ball check valve moves off its seat, this ball check valve will move off its seat, now oil from the supply chamber now there is a oil, oil from the supply chamber this supply chamber is directly connected with the engine lubrication system and this oil flows in and fills the pressure chamber. So, this oil comes in and it fills the pressure chamber, as the camshaft rotates, now when the cam shaft rotates the tappet body and the hydraulic lifter cylinder outward forcing the ball check valve onto its seat. So, when the cam shaft rotates, the camp pushes the tappet body and the temp shaft rotates the cam will push the tappet body and the hydraulic lifter and the hydraulic lifter cylinder outward. So, when the cam shaft rotates this pushes the body outward, it forces the ball check valve to move to its seat.

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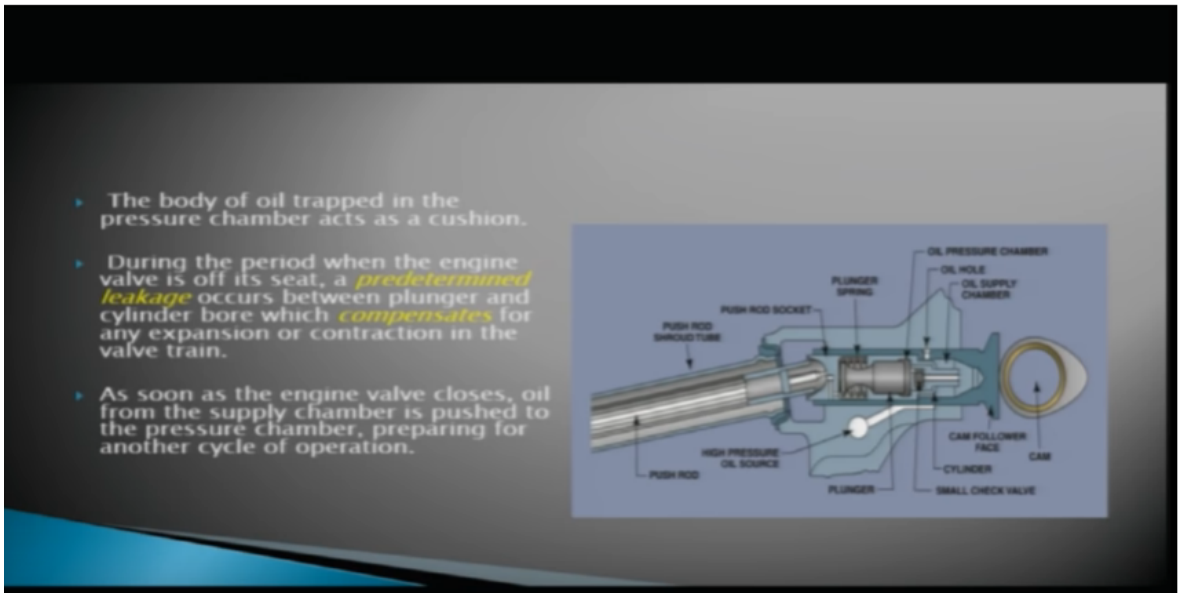

Now once the ball check valve has moved to its seat, the body of oil which is trapped in the pressure chamber acts as a cushion, then during the period when the engine always off its seat, when the that means when the valve is open there is a predetermined leakage which occurs between the plunger and the cylinder bore. So, there is a predetermined leakage which occurs between the plunger and the cylinder bore to compensate for any expansion or contraction in the valve train. So, there is a predetermined amount of leakage, which is continuously happening, to prevent or to compensate for any expansion or contraction in the ball training, as soon as the engine valve closes oil from the supply chamber. So, as soon as the valve closes the oil from the supply chamber is again pushed to the pressure, which prepares it for another cycle of operation. So, this is a small schematic diagram of the mechanism how the tappet or the valve lifter is working, now we you will see a small video of the tappet, how the tappet looks like, what are the different parts inside we will actually show you we will dismantle an actual tap it and show you the different parts, of a hydraulic tappets, also on a on an one of our engine we will show you how the valve mechanism is working what are the various parts on an actual engine, the video is followed by this lecture so, you can see it in that video.

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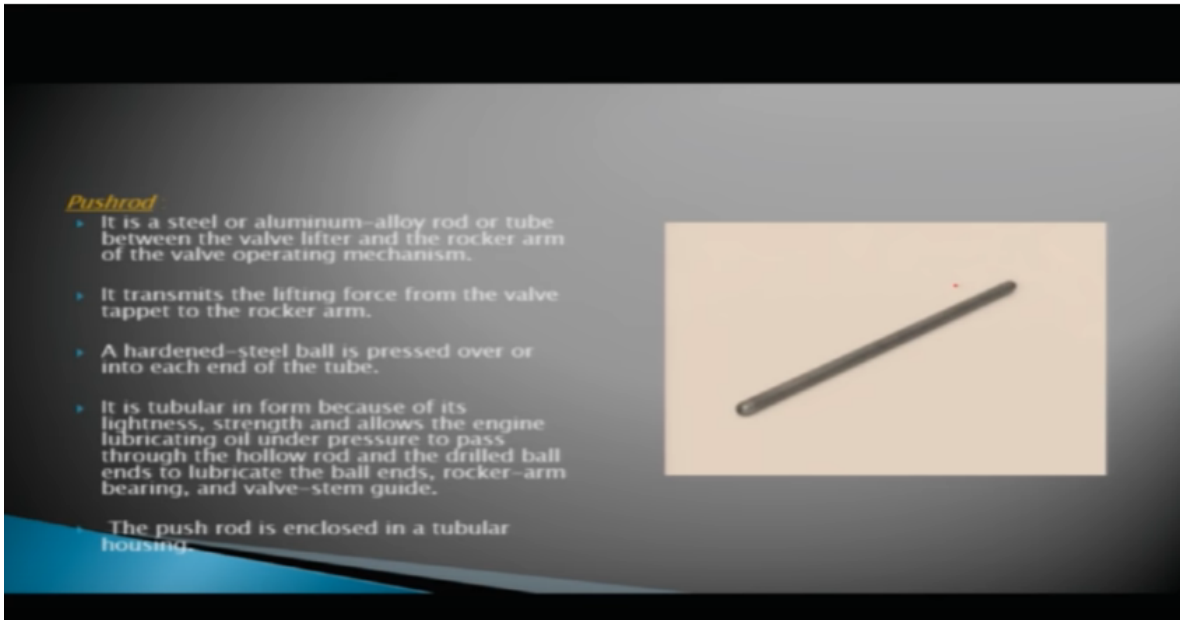

Pushrod it is a steel or aluminum alloy a rod or tube, between the valve lifter and the rocker arm of the valve operating mechanism. We have just seen in that schematic diagram, that the push rod, it is a steel or aluminum alloy a rod or tube, between the valve lifter and the rocker arm, of the valve operating mechanism, it transmits the lifting force from the valve tappet to the rocker arm. A hardened steel ball here you can see here a hardened steel ball is pressed over or into each end of the tube, it is tubular in form because of its lightness, strength and allows the engine lubricating oil under pressure to pass through the hollow rod and a drilled ball ends to lubricate the ball ends, rocker arm bearing and valve stem guide. So, this push rod this is tubular in form because, of its lightness strength and it allows the engine lubricating oil and a pressure to pass through the hollow tube, the push rod is enclosed in a tubular housing.

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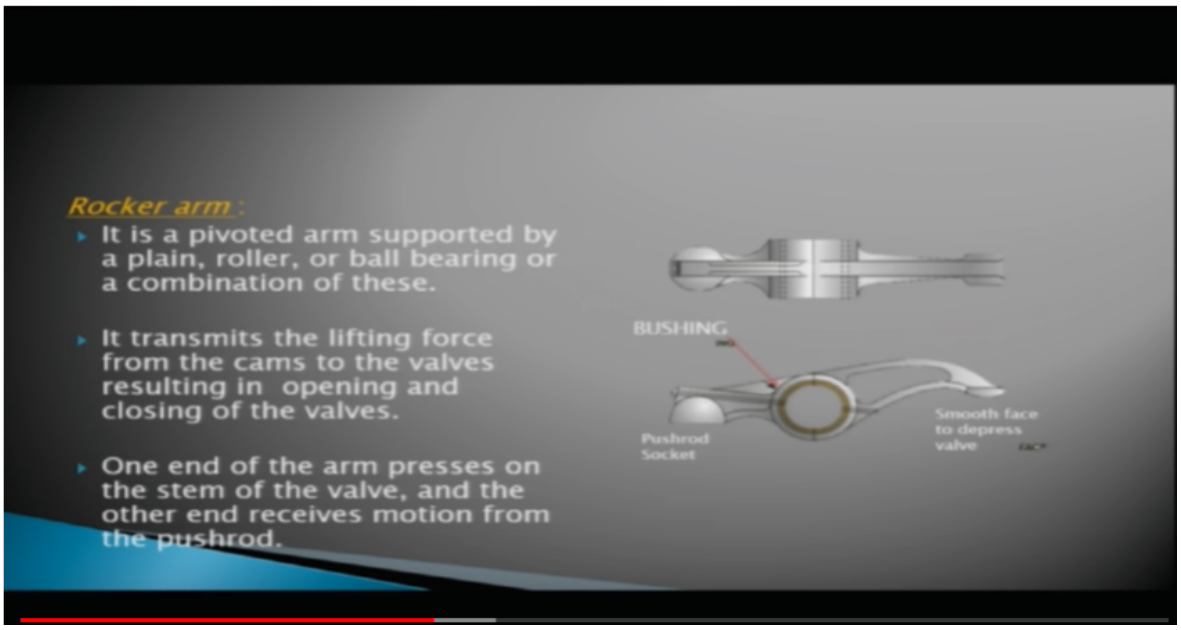

Next is rocker arm, we have also seen the rocker arm in the diagrams. So, here also you can see the rocker arm, it is a pivoted arm, see this is your pivot point supported by a plane roller or ball bearings, you have the bearings here or a combination of this it this end this is the rodent here, there is a socket which accommodates the pushrod end and this is the tip this is a smooth face to depress the valve, this rocker arm transmits the lifting force from the camps to the balls resulting in opening and closing of the valves, one end of the arm presses on the stem this end this presses on the stem of the valve and the other end receives motion from the push rod this end this receives motion from the push rod.

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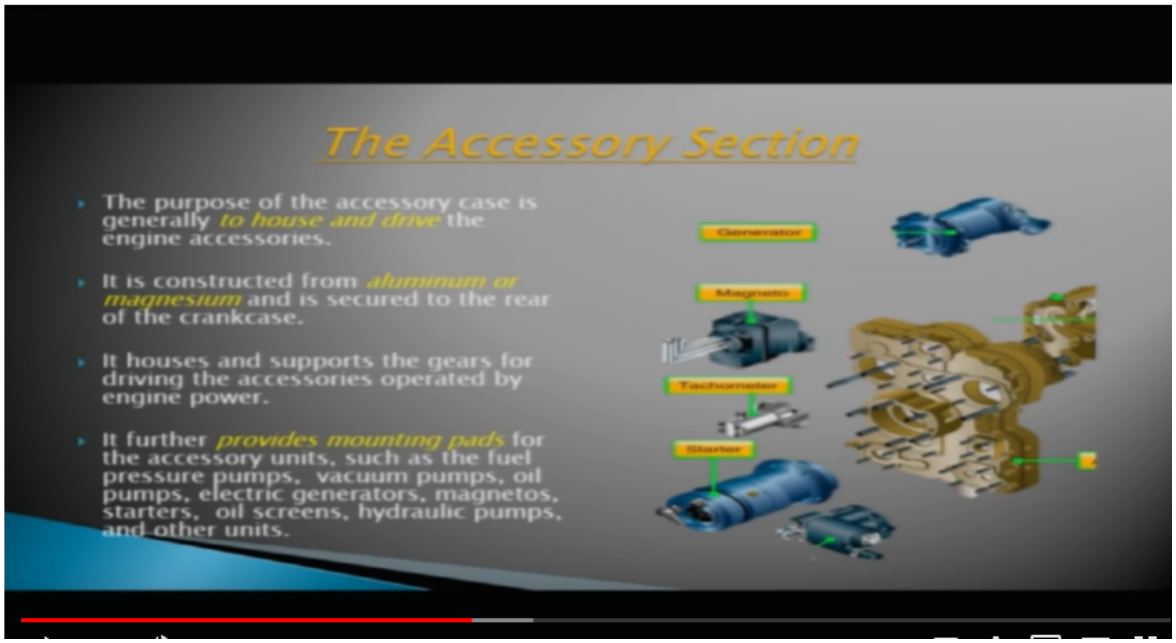

The purpose of the accessory case is generally to house and drive the engine accessories. So, on a reciprocating engine you have various accessories, here in the diagram also you can see some of the accessories shown, this is your accessory section you have, generator, magneto, tachometer, starter. So, this is the housing which accommodates all these accessories and it is called the 'Accessory Section', it is constructed from aluminum or magnesium and is secured to the rear of the crankcase. So, this accessory section, is manufactured, is constructed from aluminum or magnesium and is fixed, to the rear of the crank, it houses and supports the gears for driving the accessories. So, all these accessories they are to be driven by gears and the gears are inside the accessory housing. So, this accessory housing houses and supports the gear, for driving these accessories operated by engine power, it further provides mounting pads for the accessory units. So, here you have the mounting pads, for mounting these accessories.

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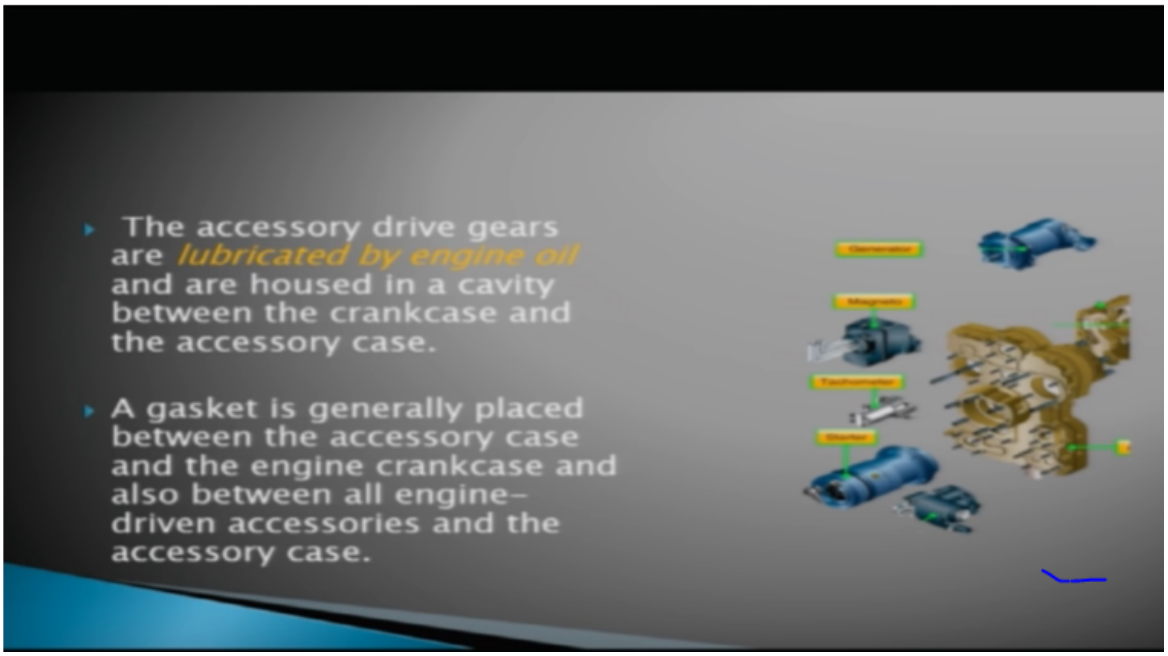

The accessory drive gears are lubricated by engine oil. So, all the accessory drive gears they are lubricated by engine oil and are housed in a cavity, between the crank case and the accessory case. So, the drive gears are lubricated by engine oil and they are housed in a cavity between the crankcase and the accessory guess, there is a gasket which is generally placed between the accessory case and engine cranking. So, between the engine crankcase and the accessory case there is a gasket and a gasket is also there between all engine driven accessories and the accessory case. So, a gasket is generally provided between the accessory case and the engine crank case and between the engine driven accessories and the accessory case.

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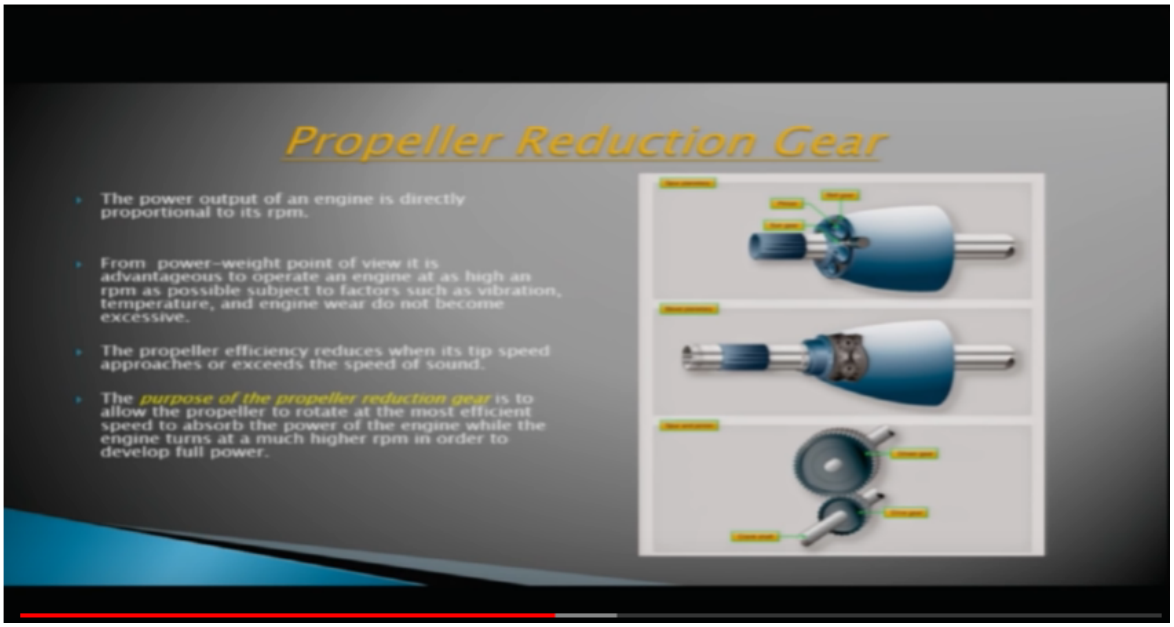

Next we come to propeller reduction gear. So, what is propeller reduction gear? Why is it required? Generally the power output of an engine is directly proportional to its RPM. So, we all know that, the greater the RPM the revolutions per minute, of a propeller the more, is the power output of the engine, from power to weight point of view it is advantageous to operate an engine at a at as high an RPM as possible subject to factors such as vibration temperature and engine wear do not become excessive. So, from power to weight point of view, the more the RPM the more power we get. But again it is subject to some factors like vibration, temperature and engine where the propeller efficiency reduces, where its tip speed approaches or exceeds the speed of sound. So, we all know that if the propeller tip, speed approaches, the sound speed or it exceeds the sound suite the propeller efficiency is going to reduce. So, now here is comes the requirement of a propeller reduction gear, the idea is that the engine should have the maximum RPM whereas with the help of reduction gear, we can reduce the RPM of the propeller. So, now we get more RPM from engine and trans with the help of a reduction gear propeller reduction gear we are able to get more efficiency, from the propeller, the purpose of the propeller reduction gear is to allow the propeller to rotate at the most efficient speed to absorb the power of the engine while the engine turns at a much higher RPM in order to develop full power. So, in order to develop full power the engine is being operated at a very high RPM and the propeller reduction gear takes care of the propeller efficiency it reduces the RPM which is transferred to the propeller.

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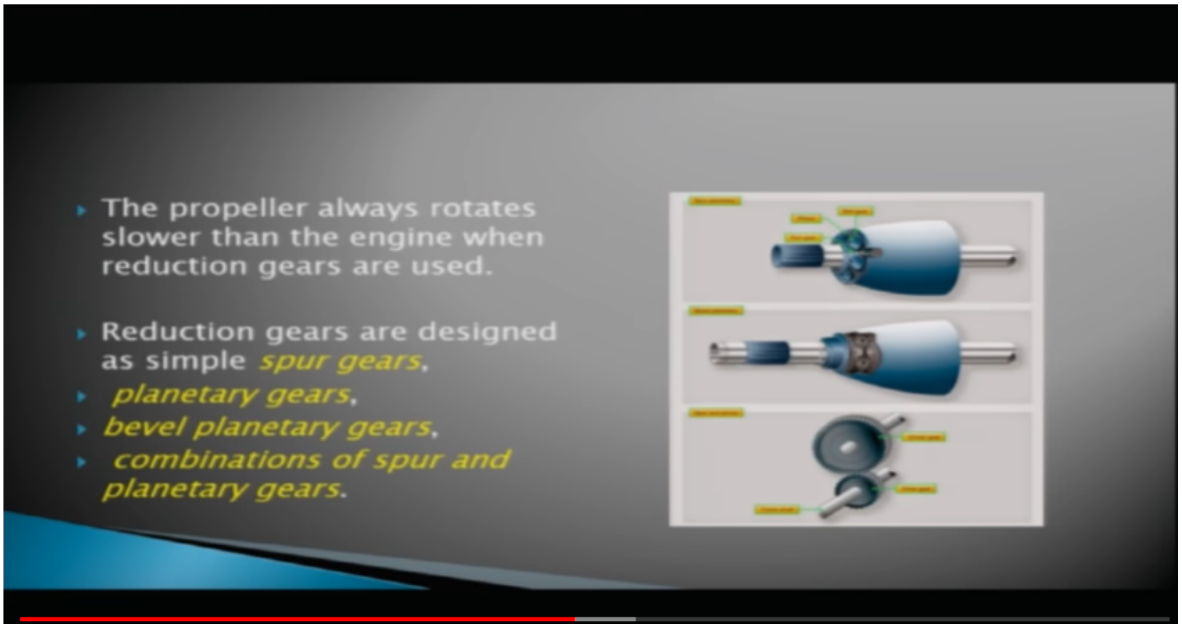

The propeller always rotates, slower than the engine, when the reduction gears are used so, with the help of reduction gears, the propeller RPM is reduced, reduction gears are designed as simple spur gears, planetary gears, bevel planetary gears and combination of spur and planetary gears. So, there are various types of reduction gears, they may be spur gears, bevel glares, bevel planetary gears, planetary gears or a combination of spur and planetary gears.

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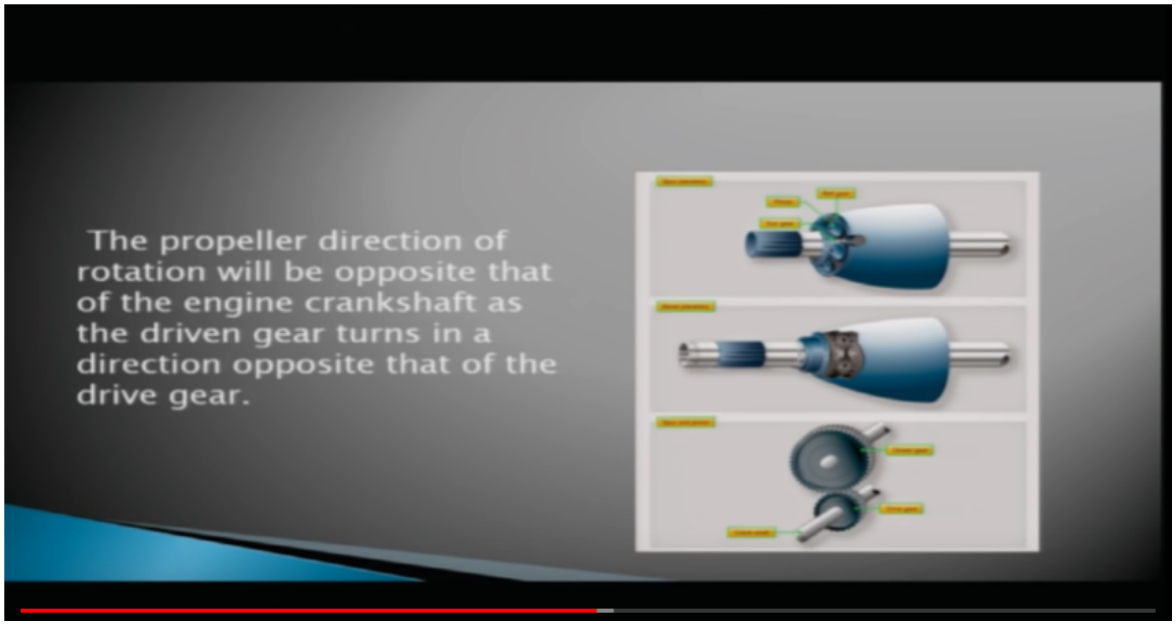

The propeller direction of rotation will be opposite that of the engine crankshaft, since, the driven gear turns, in a direction opposite to that of the drive gear. We all know that the direction of rotation of the driven gear is opposite to that of the drive gear. So, the propeller direction of rotation is opposite to the, direction of rotation of the engine crankshaft. So, this was all about, the construction, of a reciprocating engine, this whatever we have studied in this, lecture, we are going to see it on a stripped engine we will be able to see the crankshaft, the connecting rods, the valves the valve operating mechanism and the accessory section. So, you can see it in the following video. So. in the classroom we have studied about the different parts, different accessories, which form an engine. So, there is an engine in front of you which is continental oh for 70 our engine. We have stripped the engine, to see the various parts, this is your crankcase, where you can see one shaft here, this is the camshaft, we have studied about the camshaft in the class, you can see the various lobes here these are the cam lobes. This is your camshaft timing gear which is meshed with a crankshaft timing gear.

So, we will see the crankshaft. So, you can see here this is your crankshaft, which is going all through here you can see this is your crank pin this is part, of the tank chef, this is a crank cheek the crank to crank cheeks and a crank pin make a throw. We have studied in the class, what does the throw? To crank cheeks and a crank pin they make a throw. So, you can see it the shaft here one throw on this side, one throw here, one throw here. so, basically this is a 6-cylinder engine. So, three throws on this side three throws on the other side, this is your crankshaft timing gear so this is the your crank shaft here, you can see we have also studied in the class about the dampers, to dynamically balanced the shaft. So, this is your dynamic damper here. So, this is your counterweight, which is attached to the crank shaft so, that the your crank shaft is dynamically on the counterweights you have the holes in which you have the two spool pins these are the spool prints here to provide a pendulum up it so, that your crank shaft is dynamically balanced. So, this is your counter weight with your dynamic damping. We have seen it in the class. So, you've seen the

crank shaft the crank pin the tranche cheeks to crank cheeks and the crank pin make a throw, you've seen the counterweight with your dynamic balancing so at the end of the crank shaft you have the crankshaft timing gear this is your timing gear it is a spur gear. so this strand chef timing gear, meshes with the camshaft timing gear, we have seen it in the front that it's a cam there is a spur gear another spur gear and this ***crankshaft*** timing gear meshes with the camshaft timing gear, we have also seen in the class that the size of the camshaft gear double the size of the crankshaft. So, just forward of the crankshaft you have the propeller shaft here, where the propeller is mounted as a propeller chef, in the class we have seen the different types of propeller shafts the spline type, the tapered type, and the flange type, in this particular engine, the shaft is of the flange type. So, this is your flange type propeller shaft. So, we have seen the crankshaft the crankshaft timing gear as I just mentioned this is your camshaft timing gear, which is double the size of the crankshaft this is your camshaft here, this shaft this is your camshaft and these are your lobes, here you see different lobes on the camshaft. So, this is your cylinder we have studied about the cylinder you can see, a lot of cooling fins, this is this top portion is your cylinder head, this is your cylinder barrel and this is your skirt area. So, this is your cylinder this is you can see there is a hole here in the front, this hole this is for your spark plug. So, this is your spark plug hole where your spark plug fits there are two spark plugs on the cylinder, one is on this side another is on this side. So, you can see the two spark plugs these are the spark plug holes one spark plug this is your spark plug this fits in, in this hole and another spark plug on this side. So, then you have the two ports, one is the intake port and one is the exhaust port and this is your intake port and exhaust port. So, there are two, two ports intake port and exhaust port and you have the two valves, this is your valve seating area where the two valves are connected. So, this is your intake Pole and the exhaust valve here, you can see the valve stems they're coming out this is how the valve moves and this is your stem guide here, this is your valve guide here and this is your valve seat. Now you can see these, these supports here they are your rocker arm supports this, this is your rocker arm support, we have seen in the class what our rocker arm is here you can see this is your rocker arm this fritzes this area and these are your rocker arm support pins.

So, you can see the support pins here and the rocker arm is mounted here, which touches the valve here if you want to see the inside of the cylinder you can see the inside of the cylinder here. so, this is this is your cylinder, from inside you can see the cylinder inside you can see the two valves here this larger valve, this larger sized valve this is your intake valve and this is a smaller size ball this is your exhaust valve. So, two valves you can see from inside they are seated on the valve seats this is intake Paul and this is exhaust valve this area you can see here, this is your spark plug attached this side you can see this is your spark plug and this spark plug, you will see the electrode inside here this is the place where your spark is coming out when the ignition is taking place, the spark coming out of the spark plug ignites the fuel air mixture this is the place basically this is the area on top of the piston where your combustion takes place or in the cylinder head. So, this is one spark plug this is another opening for the spark plug we attach another spark plug here. So, two spark plugs mounted here they provide ignition at the proper time and the combustion takes place here. So, this is your intake Paul this is your exhaust valve, these are your spark plugs. So, here you see this is your piston. So, you can see here this is one, piston which is connected to the connecting rod this is your connecting rod here, this piston is attached to the connecting rod, there is a piston pin here, you can see this is one piston where you have the piston pin here this is your piston pin this piston pin goes inside the cylinder like this and one end of the connecting rod you can see the smaller end

of the connecting rod fix goes inside this piston pin. So, this is how the piston is attached this is your connecting rod this is and this piston pin. So, the connecting rod attaches to the piston through this piston pin, the other end of the connecting rod, this is the other end of the connecting rod, which is mounted on the crank pin of the crankshaft. So, we have seen the crank pin and the crankshaft, this is your place, where your crank pin of the crankshaft is held within this connecting rod these are your bearings you can see there are two bearings, which go inside this and these are the plane bearings inside this, this big hole which holds the crank pin of the crankshaft. So, this is you have seen the mounting of the piston on the crankshaft. Now coming to piston you can see there is a piston in front of me, this is your piston head we call it a crown, crown area this sight post motion, this is called the, 'Piston Skirt Area', you can see on top of the piston there are two recesses we have seen in the class that the piston had, had piston head had got two recesses these are the valve recesses these are two depressions here on the top of the ball. So, on this piston you can see various rings we have studied in the class there are rings different types of rings on top you can see these are the compression, rings then you have the oil control rings, they you have the grooves here on the piston between the grooves the area between the grooves is called the land this is called the, 'Land Area', top Rank's are called the, 'Compression Rings', this ring just above the piston pin hole, is your oil control ring and the ring which is just below the piston pin hole, is your oil scrapper ring. So, you can see the piston here I have the Rings here in front of me, different rings you can see, these are your compression rings this is your oil control ring ,this is your all control ring this is your scrapper ring, this is your piston pin hole, where your piston pin fits in this is the this is how the piston pin goes inside you can see this piston pin goes inside this is inside of the piston, just on the bottom of the piston and here your ones end of the connecting rod friction this is how the connecting rod fits in the piston pin. This goes through the smaller hole of the connecting rod and this end of the connecting rod, fix on the crank pin of the crankshaft. So, this is how the piston and the crankshaft are connected to each other, now coming to valve mechanism we have studied in class about the valve operating mechanism ,let me show you the different parts, which are there in the valve mechanism, you can see the two valves we have studied the different types of valves the tulip type valves, the you can see the two sides of the valves, the bigger valve, the bigger size is the intake valve, the smaller size is your exhaust valve. Now this is your valve stem area, this is your valve stem area this is your valve neck and this is your face area, this is your valve tip, this is the tip this since this is a bigger size this is intake ball and this is exhaust valve. We have seen that the exhaust valve since it is exposed to very high temperatures it is exposed to corrosive area corrosive environment.

So, this face of the valve is coated with a hardened material called 'satellite' so, on and also on the tip. So, because on the tip you have the continuous hammering of th rocker arm. So, and at the same time, the valve is grounded to a certain angle you can see the two valves, the exhaust valve and the integral they are grounded to a certain angle we have seen in the class. So, these are the balls we have seen how the balls are connected the cylinder how the valves are seated inside the cylinder we have just seen it then we have also seen the valve Springs these are your valve Springs. We have read that two springs one inside the other, are mounted so these are the two Springs you can see the two Springs which are over the valve stem they go like this just on top of the valve Springs you have this washer, it goes like this and in order to keep the complete mechanism blocked, you have the valve stamp keys these are called the locks, the keys which hold the complete unit like this it keeps it locked since it is spring-loaded is under tremendous pressure and keep the complete

mechanism locked. Now this mechanism the is this is your valve rocker arm, we have seen in the class this is your valve rocker arm, this is this end this is your tip end and this is you can see here a small hole this goes like this, this end touches your stem like this and is hinged to the rocker arm support pin here in the cylinder you see it goes like this, this, this is your rocker arm support pin these are your rocker arm supports, it is mounted like this, this pin goes inside this and it is like this, this and you can see this end this hammers the tip of the valve continuously to open the ball against the spring pressure. So, the springs keep the valve closed in order to open the valve a pressure has to be exerted, against the spring pressure to open it, the other end of the rocker arm this end is connected to the push rod this is your push rod we have seen in the class it is a hollow tube with two ball ends you can see one ball and here another ball and here plus holes so, that the oil is transferred for lubrication purpose. So, this one end of the push rod is connected to the rocker arm like this, now this push rod is inside the guide. So, you have the guide here yes like this, this guide is mounted on the crankcase engine and it goes like this. So, this is your push rod we have seen in the class what a push rod is it is a hollow tube with two balls ends one on this side and another on this side it has holes, for lubrication for transferring of oil.

So, this push rod is going through this guide you can see a guide here this is your guide this push rod goes through the guide. So, here we have arranged it so, that you have a clear picture, this is your push rod which is going through a guide this is your valve lifter we have studied at the class mode of all lifter is this is your valve lifter which is connected to one end of the cam lobe. So, here you see you can see in the engine this is your cam lope this cam lobe pushes this valve lifter here you can see this is the small lifter this is pushed by the cam lobe the ports of the cam lobe to the ball lifter is transmitted to the push rod. So, this basically the recipe the circulatory motion the rotary motion of the camera is converted to linear motion the reciprocating motion of the push rod. So, the cam dope is pushing the push rod this push rod is being pushed here. Now here you see this is your rocker arm which is being pushed by the push rod. So, when it is pushed by the push rod here this rocker arm goes down the other end of the rocker arm is connected to the valve like this, this is your tip of the and this is your valve and when this, this pushes it from here this rocker arm goes down and this valve goes down against the spring pressure. So, I'll show you here on the engine we will try to turn the engine and show you this is your cam lobe this is your valve lifter, the push rods are going through these guides this rotary motion of the cam lobes is being converted to reciprocating motion of the push rod, why are this lifter once this push rod is pushed this push rod will push the rocker arm here this is the rocker arm this push rod will push the rocker arm here and now whence this end of the rocker arm goes up the other end goes down since it has hinge in the center this end will go down. So, like this when this goes down the valve goes down we try to turn the propeller, we try to turn the engine and see how it looks like. So, see the engine is being turned now you can see the camshaft moving here, the camshaft moving you can see the various cam hopes moving now the top end of the cam lobe pushes the valve lifter you can see the valve lifter here it is moving once the valve lifter is moving you can see the push rod being moved once the push rod moves you can see the rocker arm moving and the rocker arm when it goes down you can see the spring also going down. So, this is your complete valve operating mechanism the camshaft cam hopes the valve lifters the push rods, the rocker arm, the bulb, along with the springs. So, this is your valve operating mechanism. So, we are trying to turn the engine the engine is being turned you can see the camshaft rotating, here you can see the camshaft rotating the cam lobes moving these are your valve lifters you can see the cam lobes they depress the valve lifter basically the rotary motion of

the cam shaft is converted to reciprocating motion of the and the pushrod. So, you can see the camp slope depressing the valve lifter here this is your valve lift up. So, when the camshaft is moving, the camera through the lifter it pushes the push rod the push rod this is this push rod is going through this guide, this push rod this is pushed here, you can see here this when this push rod is pushed the rocker arm, you see this rocker arm, see here this is being depressed this rocker arm, see this rocker arm ,is moving it goes up and then it pushes the valve here you can see the valve here, see this rocker arm it has being pushed here by the other end. So, this was all about the different parts that construction of the engine the reciprocating engine. Thank you.

Video end time: (38:20)