Lecture – 06

Lubrication

System

Hello, we are now starting with a new chapter called, ‘Lubrication System’. In a reciprocating engine there are a lot of rotating parts, thought of rotating metallic parts and these parts need lubrication. So, let us see what the lubrication system is all about, in a reciprocating engine.

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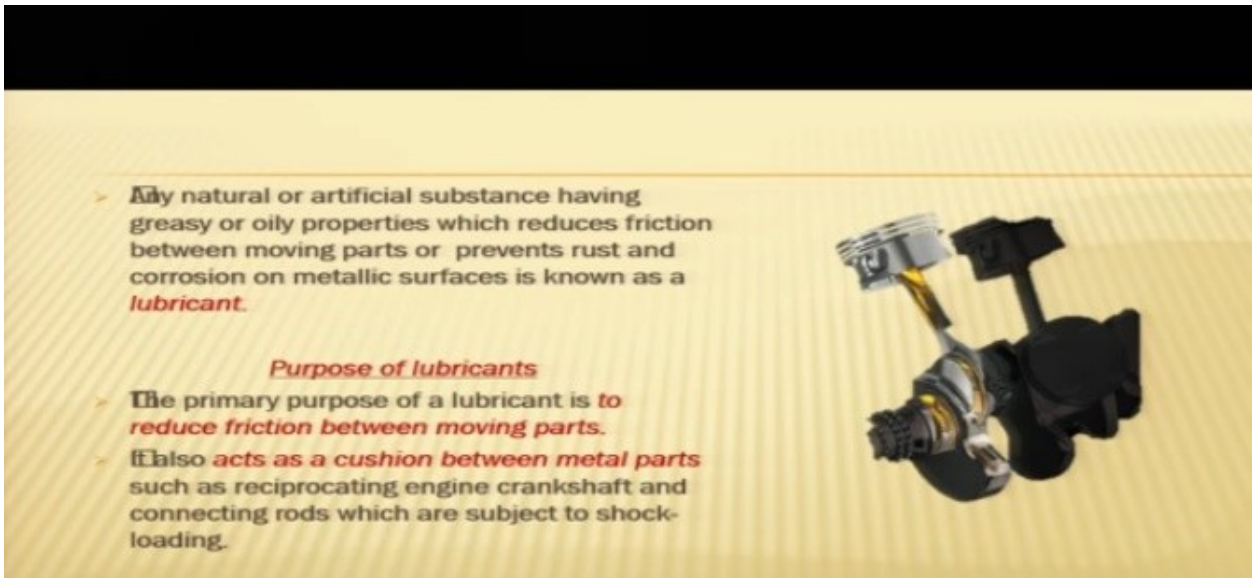

So, what is a lubricant, let us see what is a lubricant a lubricant is any natural or artificial substance having greasy or oily properties, which reduces friction between moving parts or prevents rust and corrosion on metallic surfaces is known as a lubricant so, the lubricant this reduces, friction between the moving parts we all know, when there are moving parts, friction is bound to happen so this lubricant this, substance whether it may be a natural substance or artificial substance having oily properties this reduces friction between moving parts, it also prevents rust or corrosion on metallic surfaces. So, the lubricant produces friction between moving parts and prevents rust or and corrosion on metallic surfaces. What is the purpose of lubricant, the primary purpose of a lubricant is to reduce friction? Between moving parts as, we have just seen in the above definition the main purpose the primary objective of a lubricant is to reduce friction between moving parts, it also acts as a cushion between metal parts such as reciprocating engine crankshaft and connecting rods which are subject to shock, loading so this lubricant is also acting as a cushion, between metallic parts the example is given like reciprocating engine crankshaft and connecting rods as, they are subjected to shock loading so, we have seen, lubricant it is a natural or artificial substance having greasy or oily properties it reduces friction between moving parts and also prevents met like parts from rust and corrosion, it also acts, as a cushion between metallic parts such as reciprocating engine crankshaft and connecting rods as, they are subjected to shock loads

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Now, oil on circulation through the engine absorbs heat, from the parts such as Pistons and cylinder bolts, oil also absorbs heat now, when the oil is circulating through the, system through the engine, it will absorb heat from the parts such as piston and cylinder walls, we all know pure layer combustion is happening inside the cylinder over the piston, so the piston and cylinder walls they, are subjected to lot of heat, oil on circulation will absorb this heat from the piston and cylinder walls, it also forms a seal between the piston and cylinder wall to prevent leakage of the gases from the combustion chamber so, oil in addition to absorbing heat, also forms a seal between the piston and a cylinder wall to prevent leakage of the gases from the combustion chamber it also reduces abrasive wear by, picking up foreign particles and carrying them to a filter where they are removed, so oil is also reducing a breath severe by, picking up the foreign particles and moving them to a filter where they are removed, so we have seen oil has got various purposes it is, reducing friction between the moving parts, it prevents rust and corrosion on metallic parts it is, absorbing heat from the parts such as pistons and cylinder walls, it also forms a seal between the piston and the cylinder wall to prevent leakage of the gases from the combustion chamber and it is also reducing impressive wear by, picking up foreign particles and carrying them to a filter.

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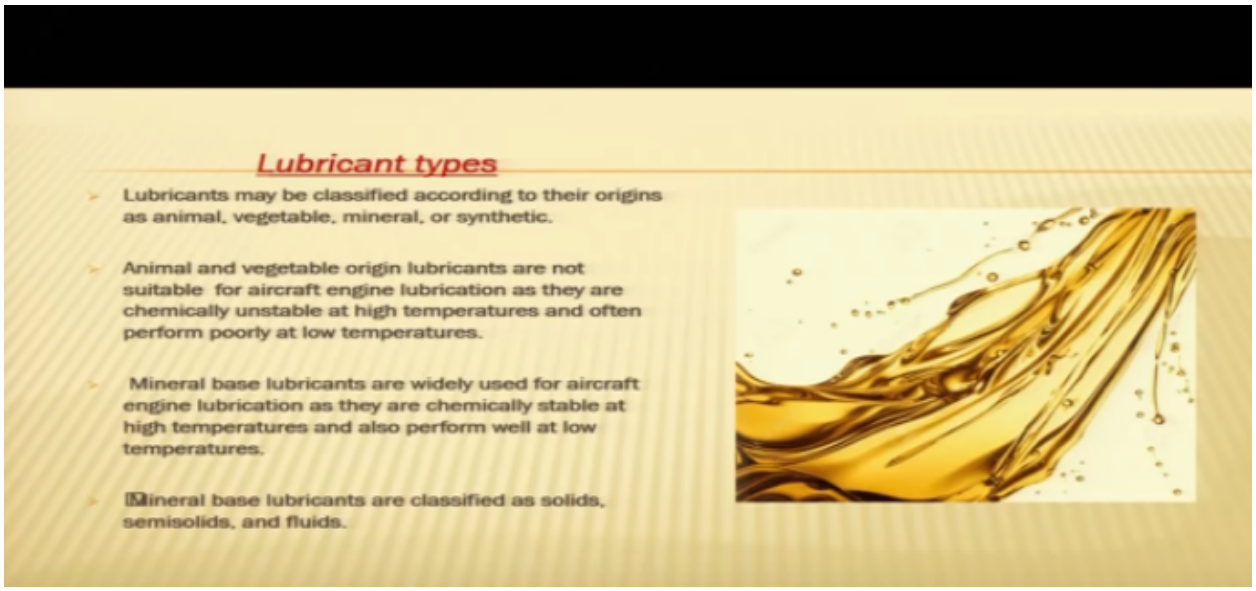

Now, what are the different lubricant types? Let us see the types of lubricants; lubricants may be classified according to the origin as, animal, vegetable, mineral or synthetic. So, lubricants are produced from various sources they are classified according to the origin, like it can be animal lubricant, vegetable lubricant, mineral lubricant ,synthetic lubricant, in case if it is, produced from animal remains, it has an animal loop type lubricant in case if it is produced from vegetable remains, it is a vegetable lubricant and further we have, mineral or synthetic lubricant now, animal and vegetable origin lubricants they are not suitable for aircraft engine lubrication as, they are chemically unstable at high temperatures and often perform poorly at low, temperatures now we all know, that the aircraft engines they are operating at very high temperatures the temperatures are pretty high, because of fuel and air combustion because, they operate in very hot, climate so at the same time these aircrafts, these aircraft engines they also operate at very low temperatures so, the aircraft's are being operated all over the world in different types of climates so, these animal and vegetable origin lubricants they are not suitable for, aircraft engine lubrication because, they are chemically unstable at high temperatures and also at low temperatures mineral based lubricants are widely used for aircraft engine lubrication as they are chemically stable, at high temperatures and also perform well at low temperatures. So, we have seen above, that the animal and vegetable origin lubricants, they are chemically unstable at high temperatures, as well as, at low temperatures whereas on the other hand, you have mineral based lubricants which are chemically stable, at high temperatures and are also performing well at low temperatures. So, mineral based lubricants are widely used for aircraft engine lubrication now, mineral based lubricants they are further, classified as solids, semi solids and fluids. So, we have seen the clarification of mineral based lubricants solids, semi solids and fluids.

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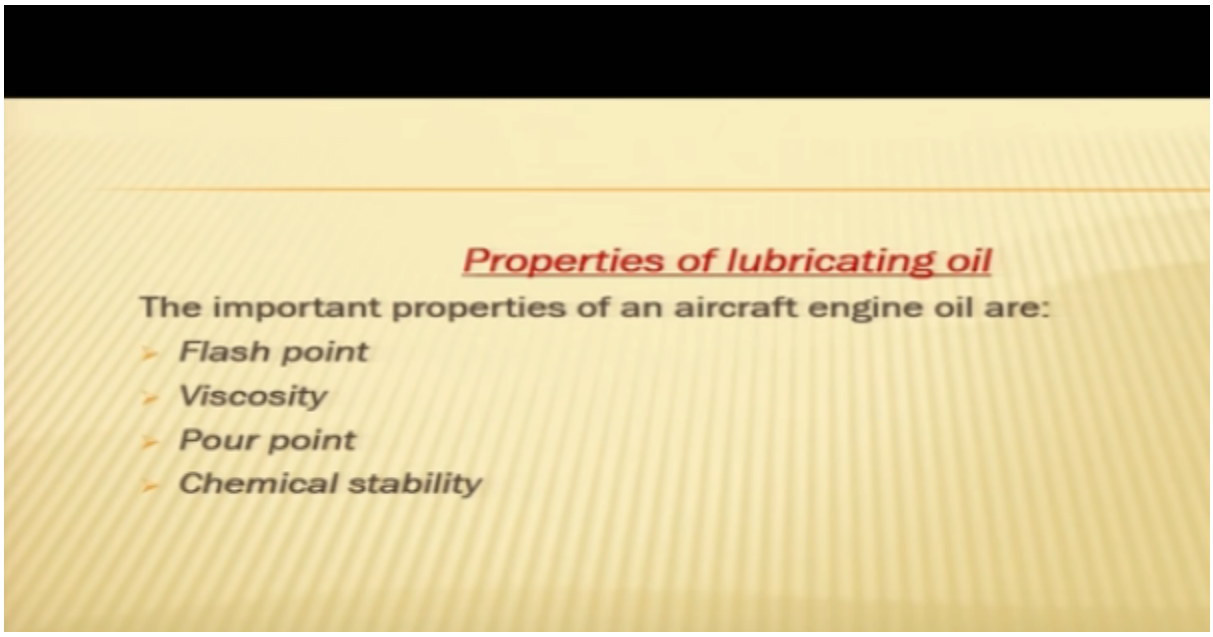

Now, coming to properties of lubricating oil, there are various properties of a lubricating oil, water lubricating oil is supposed to have, some of the most important properties are mentioned here, they are flash point, viscosity, war point and chemical stability. So, there are a few, important properties like flashpoint, viscosity, war point and chemical stability.

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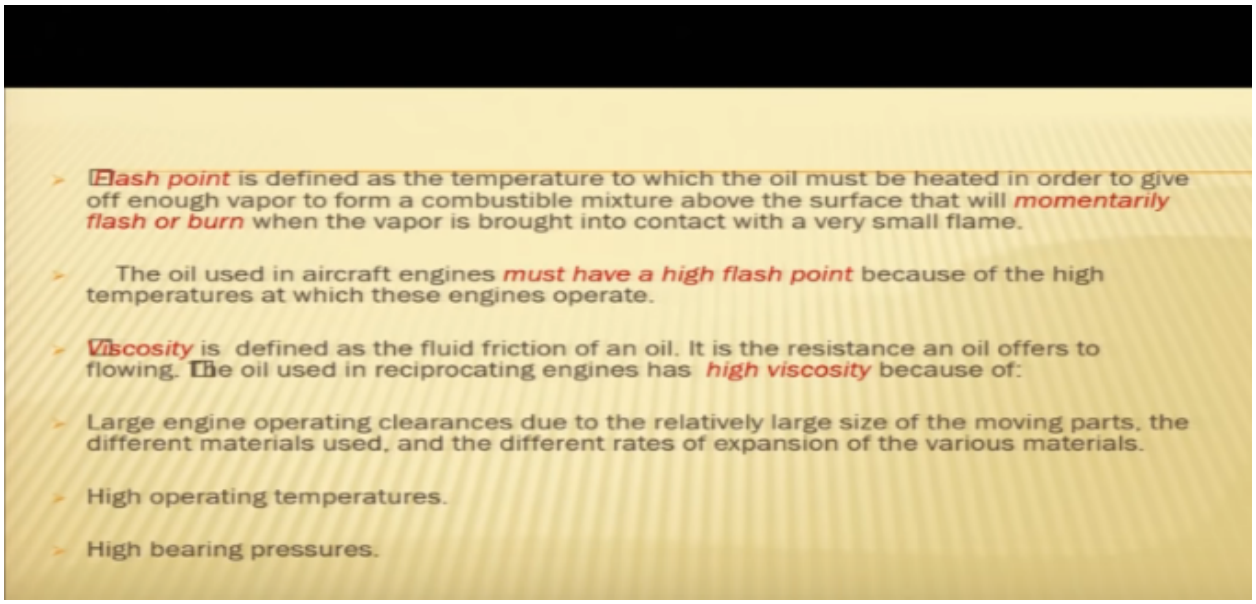

Now, what is flashpoint, flash point is defined as the temperature to which the oil must be heated, in order to give off enough vapor to form a combustible mixture above the surface that will momentarily flash or burn when the vapor is brought into contact with a very small flame. So, flashpoint is, the temperature at which the oil must be heated. So, that it gives off vapor, in sufficient quantity to form a combustible mixture, that will flash or burn when the vapor is brought into contact with a very small flame, so it is just giving momentary flash or burn the oil used, in aircraft engines must have a high flash point so, the lubricants being used in aircraft engines they are required to have a high flash point, because of the high temperature at which these engines operate. So, flash point we have seen. It is the temperature at which the oil must be heated, to give off enough vapor to form a combustible mixture above the surface that will momentarily flash or burn when the vapor is brought into contact with a very small flame. So, flash points it is the temperature at which the vapor, will momentarily burn when it is brought in contact with a very small flame. So, all the aircraft engine oils, being used all the lubricants aircraft engine lubricants must have a high, flash point next is viscosity, viscosity is defined as the fluid friction of an oil, it is the resistance and oil offers to flowing, so viscosity it is the resistance what an oil offers to flow, the oil used in reciprocating engines have higher, viscosity because of the falling grease large, engine operating clearances due to the relatively large size of moving parts, the different materials used and the different rates of expansion of the various materials. So, the oils you being used in the reciprocating engines, they have high viscosity because, of large operating clearances, due to large size of moving parts variety of materials being used and the different rates of expansion of the various material high, operating temperatures and high bearing pressures so, you have engines being operated at very high operating temperatures, you have, very high bearing pressures, you have large operating clearances you are, operating at different materials, the different materials have, different rates of expansion. So because of, all these reasons, the lubricants being used the oils, being used in the reciprocating engines, have a high viscosity. So, in this slide we have seen the flashpoint Andres casa t the aircraft engine lubricants they are supposed to have a high, flash point and high viscosity

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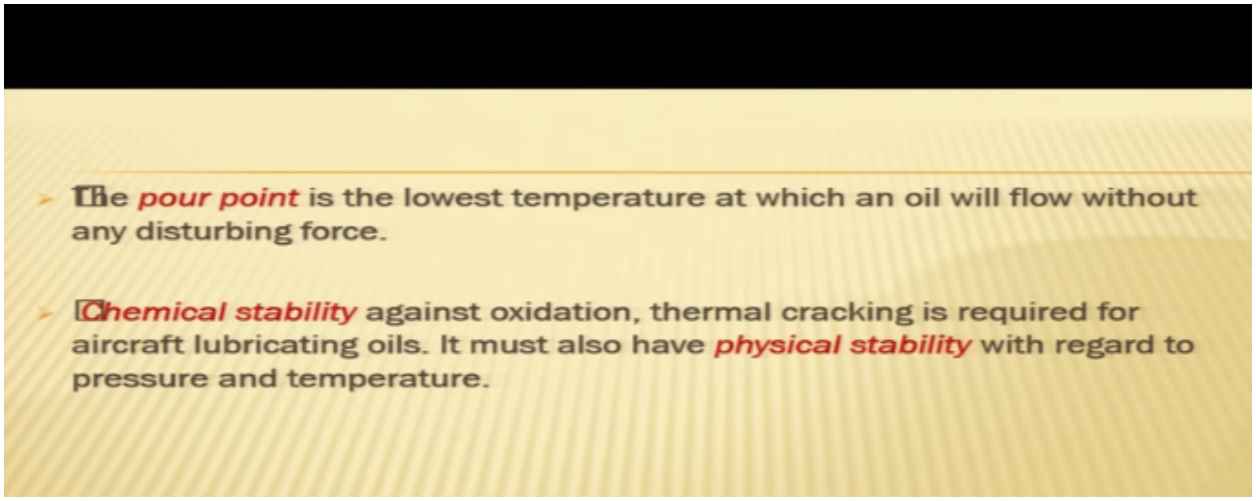

Next is, the pour point, pour point is the lowest, temperature at which an oil will flow, without any disturbing force. So, what is four point, pour point is the lowest temperature, at which and oil is supposed to flow, without any disturbing force. So, lowest temperature at which an oil is flowing, is the, poor point. Next is chemical stability so, the aircraft lubricating oils, lubricants they are supposed to be chemically stable, against oxidation and thermal cracking they are, also supposed to have, physical stability with regard to pressure and temperature. So, your lubricants they need to be chemically stable and physically stable.

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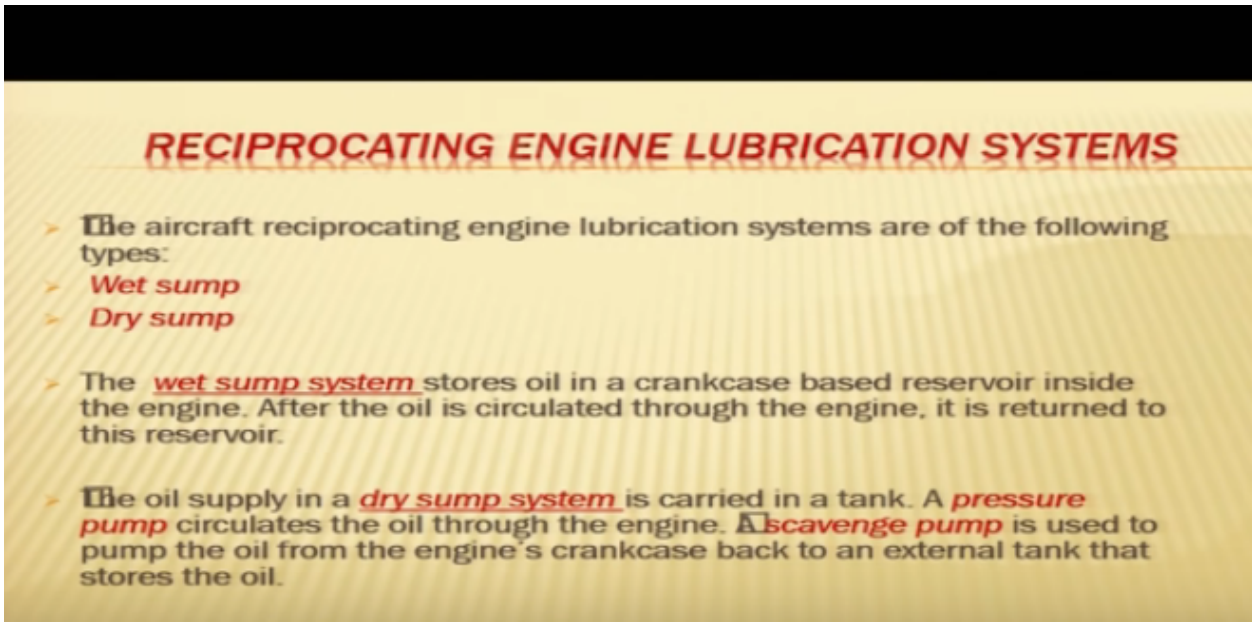

Now, coming to the reciprocating engine lubrication systems, in the aircraft reciprocating engine, we have two types of lubrication systems, the wet sump system and the dry sump system, the wet sump system stores oil, in a crankcase based reservoir inside the engine, after the oil is circulated through the engine it is returned to this, reservoir. So in the right subsystem you don't have an, independent reservoir, the reservoir it is integral with the engine it is the oil, is stored in a crankcase based reservoir, inside the engine and oil after lubricating all the power of the engine is, returned back to this, reserved oil. Second system is the dry sump system, in some of the aircrafts, we have a dry sump lubrication system, in this system there is an independent tank for storing the oil. So, the oil supply in a dry sump system is carried in a tank a pressure pump circulates the oil through the engine so, there is a pressure pump which circulates the oil, which takes the oil from the tank and circulates the oil through the engine, it also, has a scavenge pump which is used, to pump the oil from the engine crankcase, back to an external time that stores the oil. So, the purpose of the scavenge pan pump, is to push the oil back to the tank, after the engine is lubricated. So, we have seen in the slide there are two systems, two lubrication systems in different aircrafts we have different systems, some aircrafts have got a wet sump lubrication system and some aircrafts have dry sump lubrication system, wet sump lubrication system you have, oil stored in the

engine, the storage is, in the crankcase base reservoir you don't have an, independent oil tank, whereas in a dry sump lubrication system there is an independent oil tank which stores the oil, for lubrication the pump, circulates the oil through the end and there is another pump called as, ‘Scavenge Pump’ fatal from the engine crankcase back to the external tank, after the oil has done, has completed the lubrication.

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Now, apart from, the wet sump and the dry sump lubrication system, the engine is lubricated by, various method the various moving parts of an internal combustion engine are lubricated by, one of the following three methods, pressure type, splash or a combination of pressure and splash. So, the engine, is lubricated by, either pressure method, splash method or a combination of pressure and splash method, the principal method of lubricating aircraft engines is the pressure lubrication system. So, in most of the engines, the principal method of lubricating the engine is the pressure lubrication system, flash lubrication may also be used in addition to pressure level lubrication but, it is never used by itself. So in addition to the pressure lubrication splash lubrication is also used but, only splash method will never be used. So the aircraft engines are always lubricated by, either the pressure type or the combination pressure and splash type the internal parts of the engine are lubricated by, pressure method, splash method or a combination of pressure and splash method, splash method is not used, it is not used alone. So it may be either, the pressure types lubrication or it may be a combination of pressure and splash method. Now, the pressure lubrication method it has, its own advantages, it provides, positive introduction of oil to the bearings, so the bearings you get a positive oil supply, large quantities of oil that can be pumped or circulated through bearings provides cooling effect. So, in pressure lubrication large quantities of oil can be pumped, through the bearings and it provides cooling effect and it has satisfactory lubrication in various attitudes of flying now, since the aircraft will be operating at various attitudes. So, in all kinds of attitudes of flight, the pressure lubrication provides the pressure method of lubrication provides a satisfactory result so, these are

the advantages of pressure lubrication system, positive introduction of oil to the bearings, large quantities of oil to the bearings providing cooling effect and satisfactory lubrication in various attitudes of flight.

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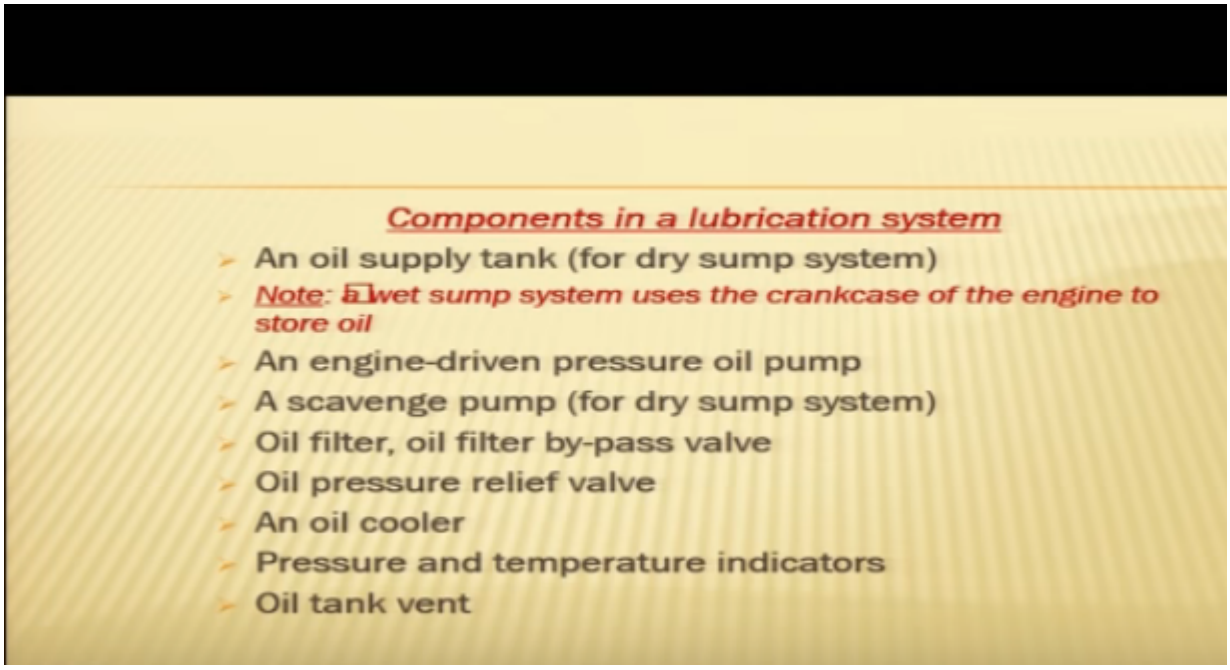

Now, coming to the components, in a lubrication system there are various components in a system, first is the oil supply tank, we have just seen it is required, in case of a dry sump system in our wet sump system, oil is stored in the crankcase. So, oil supply tank is required, in a dry sump system of lubrication. Another component is the engine driven, oil pressure pump we will see, the function of oil pressure pump it is an, engine driven oil pressure pump. Next is, a scavenge pump again, it is required, in the dry sump system we have just seen, why it is required scavenge pump it brings the oil back to the storage time after lubrication next is, your oil filter and the oil filter bypass valve, oil filter the basic purpose is filtering the oil, another component is the oil pressure relief valve, we will see what is the function of oil pressure relief valve, an oil cooler, pressure and temperature indicators and oil tank vent. So, you have various components in the lubrication system, oil supply tank pressure pump; scavenge pump, oil filter, oil filter bypass valve, oil pressure relief valve, oil cooler, pressure indicator, temperature indicator and oil tank vents.

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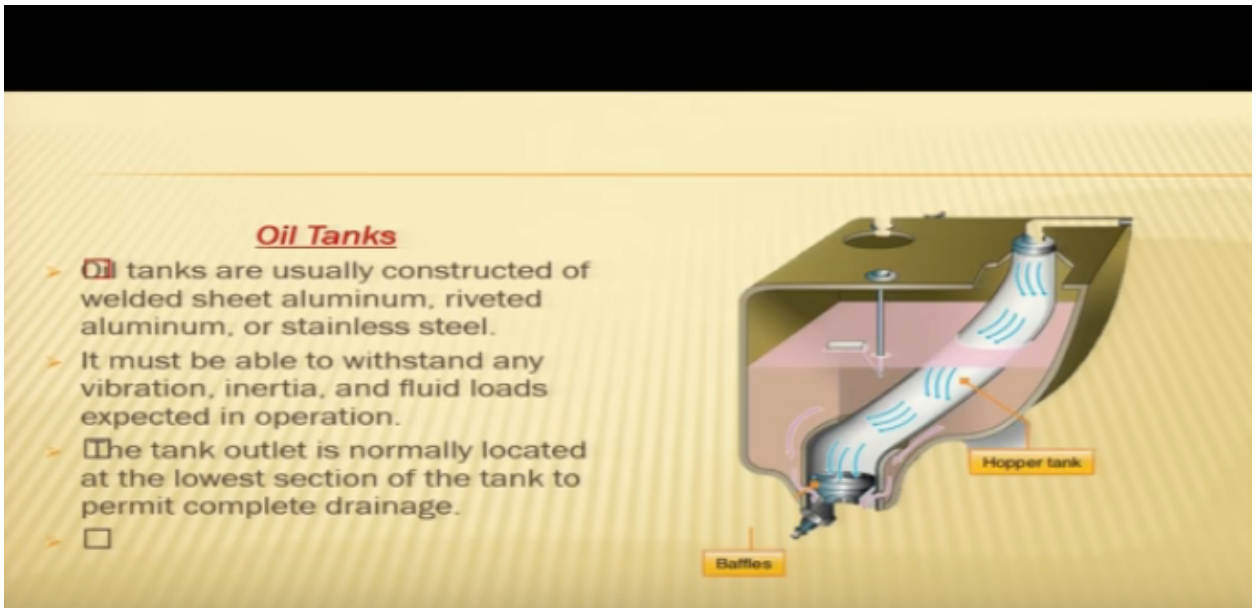

So, let us see one by, one coming to oil tank, you can see in the picture, there is a oil tank, oil tanks are usually constructed of welded sheet aluminum or riveted ammonium or stainless steel. So, these aircraft engine oil tanks usually made of, welded aluminum sheet, riveted aluminum or stainless steel, it must be able to withstand any vibration, inertia and fluid loads expected in operation. So, oil tanks they must be able to withstand vibration, inertia and fluid loads that are expected in all kinds of operation. We know, that the aircraft's they are going to operate in various attitudes, in various climatic conditions. So, the oil tanks are designed, to withstand, any kind of vibration, inertia and fluid loads. The tank outlet is normally located at a lowest section of the tank, to permit complete drainage. So, in order to permit complete drainage, while removing the oil, we have to drain the oil at various occasions, at regular intervals. So, the drain is provided at the lowest section of the tank. So, that you are able to, drain the oil completely,

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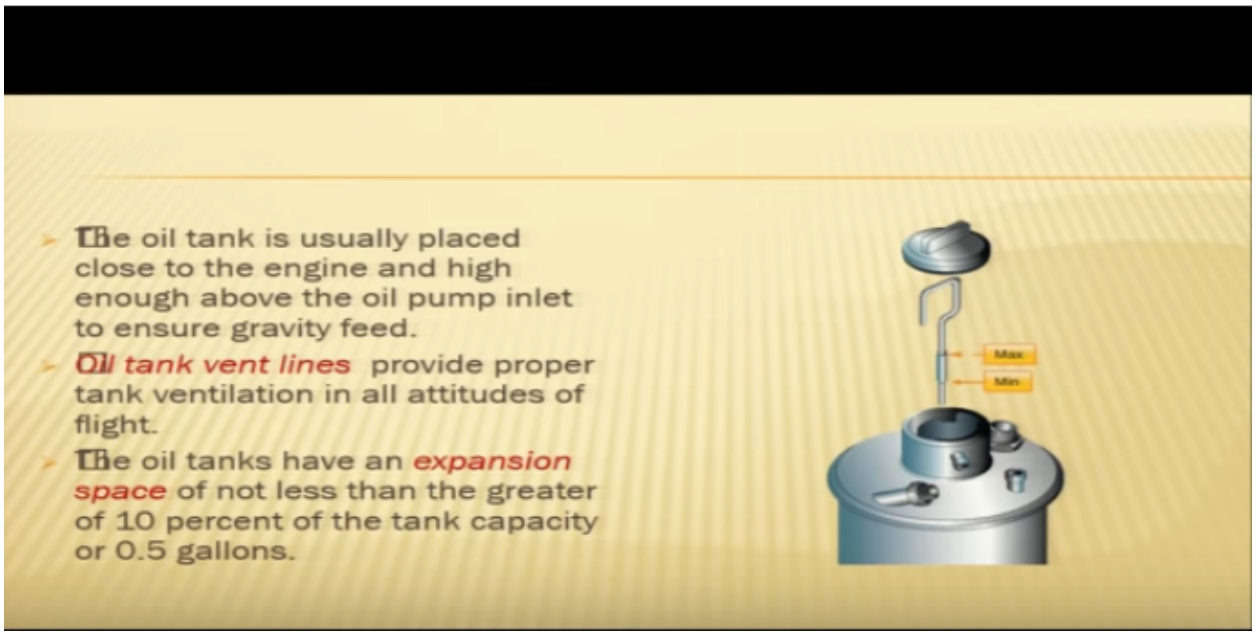

the oil tank is usually placed close to the engine. So oil tank is always placed close to the engine and high, enough above the oil pump Inlet, to ensure gravity feeds. So, oil tanks they are generally placed close to the engine and they are, also placed above the oil pump Inlet so, that the oil pump Inlet has a, gravity feed of oil, oil tank event lines provide proper tank ventilation in all attitudes of flight. So, the tanks are vented very, important the oil tanks they need to be vented these, vent lines they provide proper tank ventilation in all attitudes of flight, the oil tanks have an expansion space, of not less than greater of 10%, of the tank capacity or 0.5 gallons. So, all the oil tanks, they also need to cater for the expansion space which can not be less than, the 10%, of the tank capacity or 0.5 gallons, whichever is greater. So, we've seen, the oil tanks they are to be placed, close to the engine and also above, the oil pump Inlet to ensure gravity feed, the vent lines are provided to provide proper tank ventilation in all attitudes of flight and the oil tanks are supposed to have an expansion space of not less than, 10% of the tank capacity or 0.5 gallons whichever is greater the oil tanks are made of

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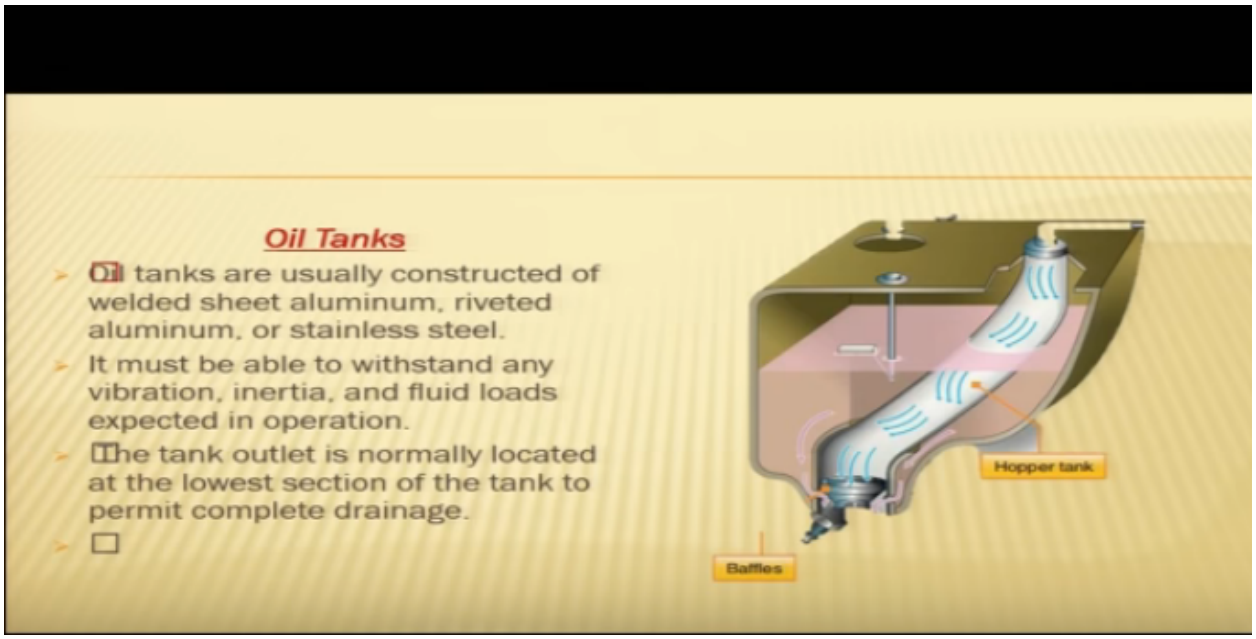

Welded sheet aluminum, riveted aluminum or stainless steel, they must be able to withstand vibration, inertia and fluid loads. Which the tanks may encounter, in any kind of operation the tank outlet is generally located at the lowest section of the tank to permit complete drainage.

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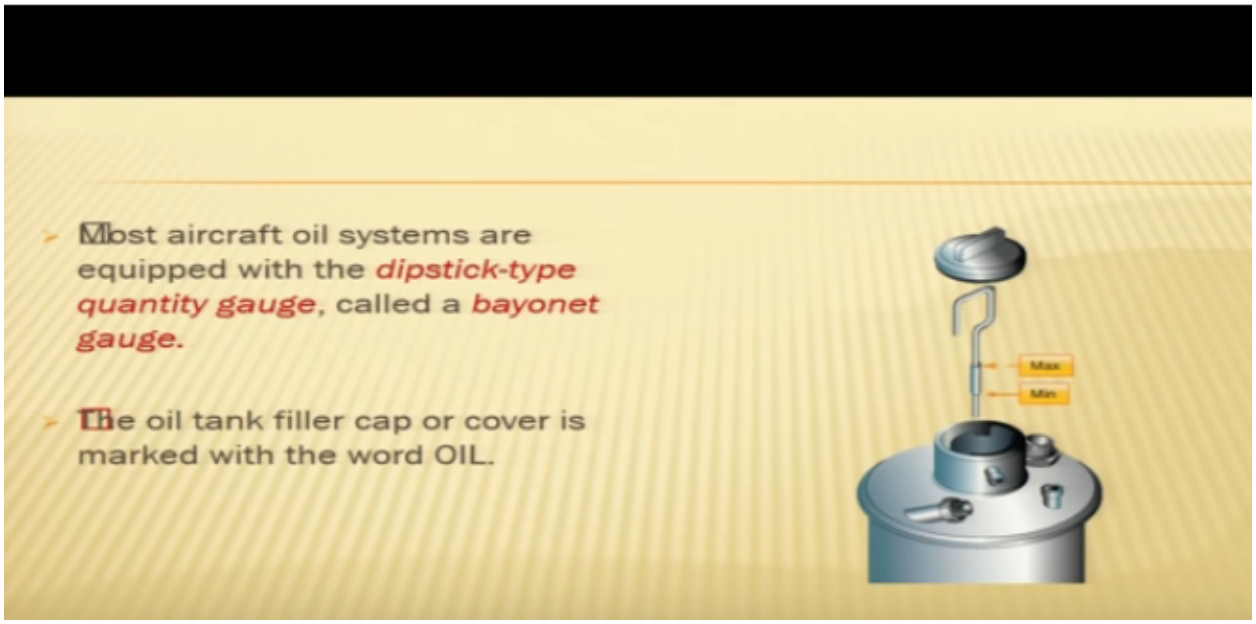

Now, most aircraft oil systems are equipped with a dipstick type quantity gauge called a 'Bayonet, Bayonet Gauge'. So, in our following video you will see, we will show you, different oil dipsticks we will show you the different, types of lubrication systems on different aircrafts, we will show you the wet sump, lubrication we will show you the dry sump lubrication, there you will see the dipstick, the dipstick is used to measure the quantity of oil in your tank and it is called a 'Beyond Gauge'. In the figure you can see, one tank is shown and the dipstick is shown in the dipstick you can see the, minimum mark as well as, the maximum mark. So, you see this is your minimum mark, this is your minimum mark and this is your maximum mark, we will show you on the aircraft also in the dipstick so, this is, just an illustration to show how, the dipstick is like the oil tank filler cap or cover this is, your oil tank filler cap or cover is marked with the word, oil just to pluck card, that this is, your oil tank and this is, the cap or the oil so oil is also written over the cap.

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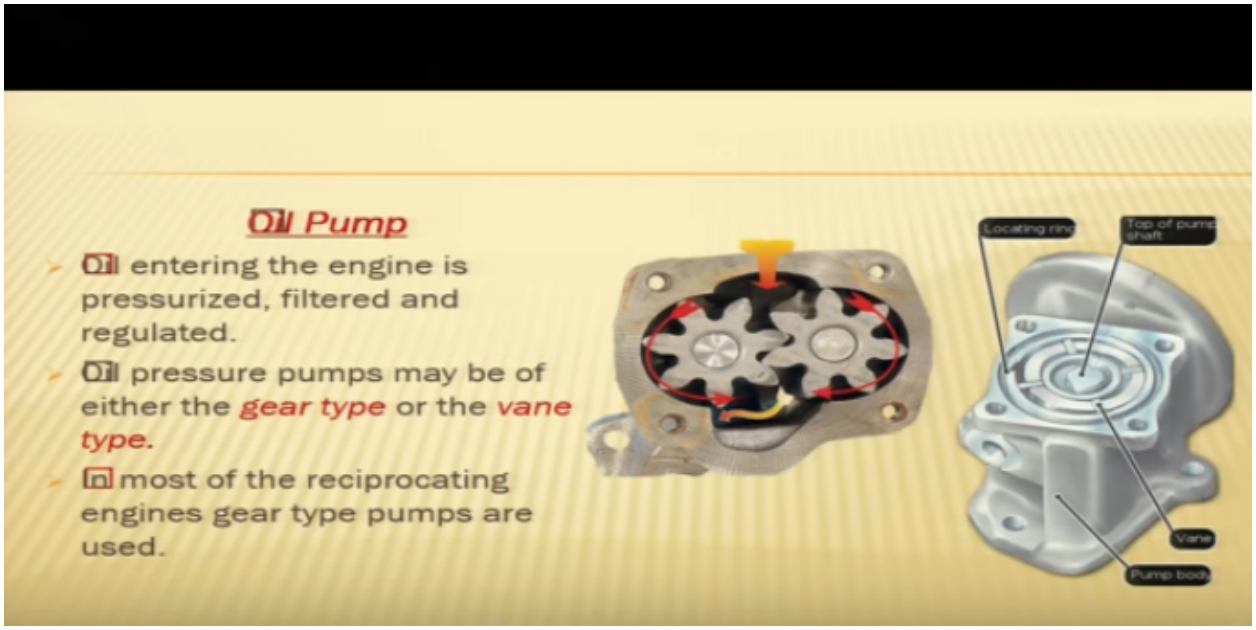

Next is your oil pump now, oil pump it is, a very important component of the oil lubrication system the purpose of the oil pump is to pressurize, the oil before it, enters the engine moving parts before it reaches the rotating parts, the oil is to be pressurized, the oil which is to move inside the engine for lubrication purpose it needs to be pressurized, it needs to be filtered and at the same time it also needs to be regulated, the purpose of the oil pump is to pressurize the oil, for lubrication, the oil pressure pumps they may be, gear type pumps or the Wayne type pumps so here in the picture you can see, that a gear type pump has been shown, will see the this is, one gear and this is, another gear in most of the reciprocating engines, gear type pumps are used so, the oil pump the purpose of the oil pump is to pressurize the oil, most of the reciprocating engines gear tie pumps are being used.

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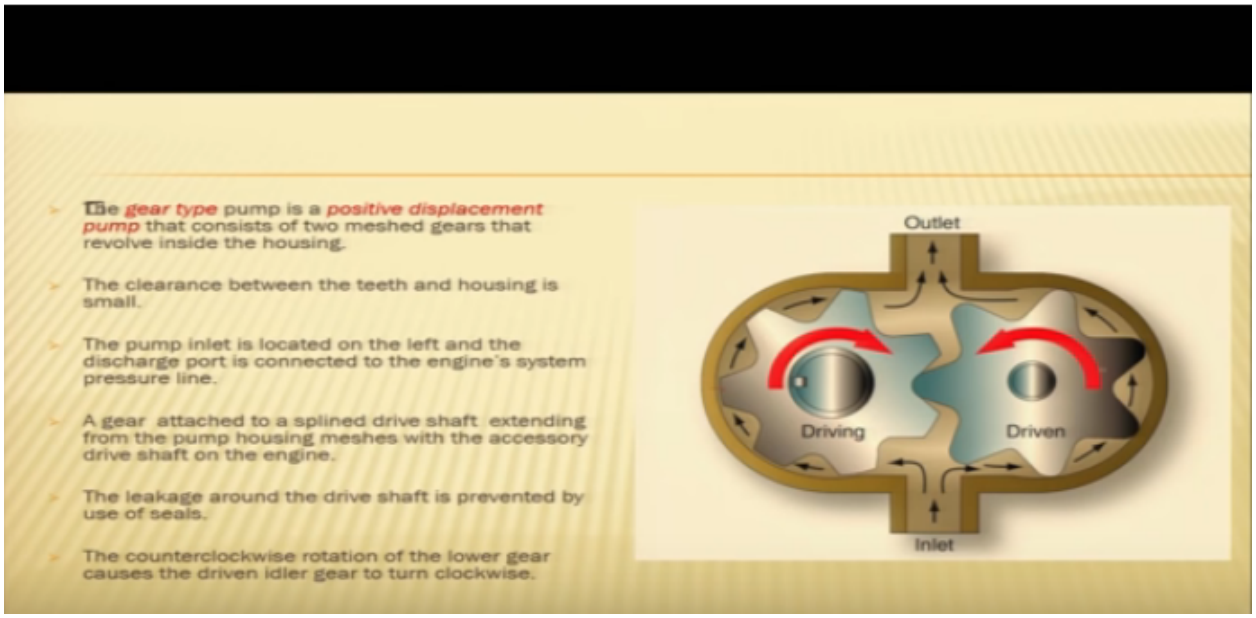

The gear die pump is a positive displacement pump that consists of two meshed gears that revolve inside the housing. So, the, that meshed gears. So, that you can see the two gears here, this is your driving gear and this is your driven gear, two gears which are meshed to each other. So, this gear tie pump this is a positive displacement pump which has, two meshed gears revolving inside the housing so, this is your housing, inside the housing two gears are revolving the clearance between the teeth and housing is small, so the clearance between these teeth and the housing is very small, the pump Inlet is located on the left and the discharge boat on the engine. So, this is your pump Inlet you see, the pump Inlet and this is your pump outlet this, pump outlet is connected to the engine system pressure line. So, the oil enters from this intellect port, it is picked up by, the gear here and is being compressed, is being pressurized, between the this driving gear and the housing of the pump so, this oil is being pressurized here, this oil is, also this is the driven gear, you can see the direction of rotation the driving gear is being rotated clockwise and the driven gear is rotated counterclockwise, so the oil this side is also being pressurized between the gear and the casing, oil after pressurization goes, through this outlet to the engines system pressure line again, attached to a splined drive shaft, extending from the pump housing meshes, with the accessory drive shaft on the engine. So, we will show you, in one of the videos an oil pump which has a, drive ship which is extending from the pump housing and meshing with the accessory drive shaft on the engine, the leakage around the drive shaft is prevented by use of seals. So, we have to ensure that there is no leakage around the drive shaft, the counterclockwise rotation of the lower gear, causes the driven idler gear to return clockwise. So we have seen that the driving gear and a driven gear in this figure you can see, the driving gear rotating clockwise and the driven gear is rotating counterclockwise so, the direction of rotation of the two gears, will be opposite

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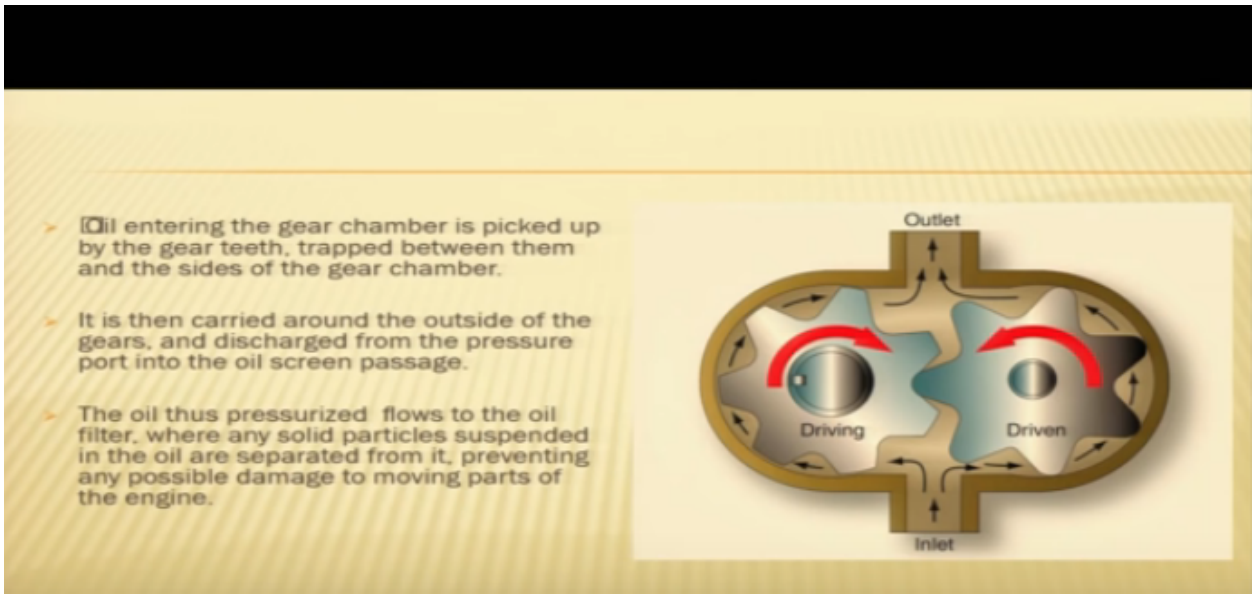

Oil entering the gear chamber is picked up by the gear teeth, I have just mentioned that it is picked up by, the gear teeth, trapped between them and the sides of the gear chamber. So, this oil is picked up by this gear teeth and strapped between the teeth and the gear chamber, it is then, carried around the outside of the gears and discharged from the pressure port into the oil screen passage. So now, this oil is pressurized here and goes through this outlet, the oil does pressurized flows to the oil filter now, oil after being pressurized, close to the oil filter where any solid particles suspended in the oil are separated from it, preventing any possible damage to the moving parts of the engine. So, after the oil is pressurized, it flows to the oil filter, where it is filtered and filters out any suspended solid particles thus preventing any possible damage to the moving parts inside the engine.

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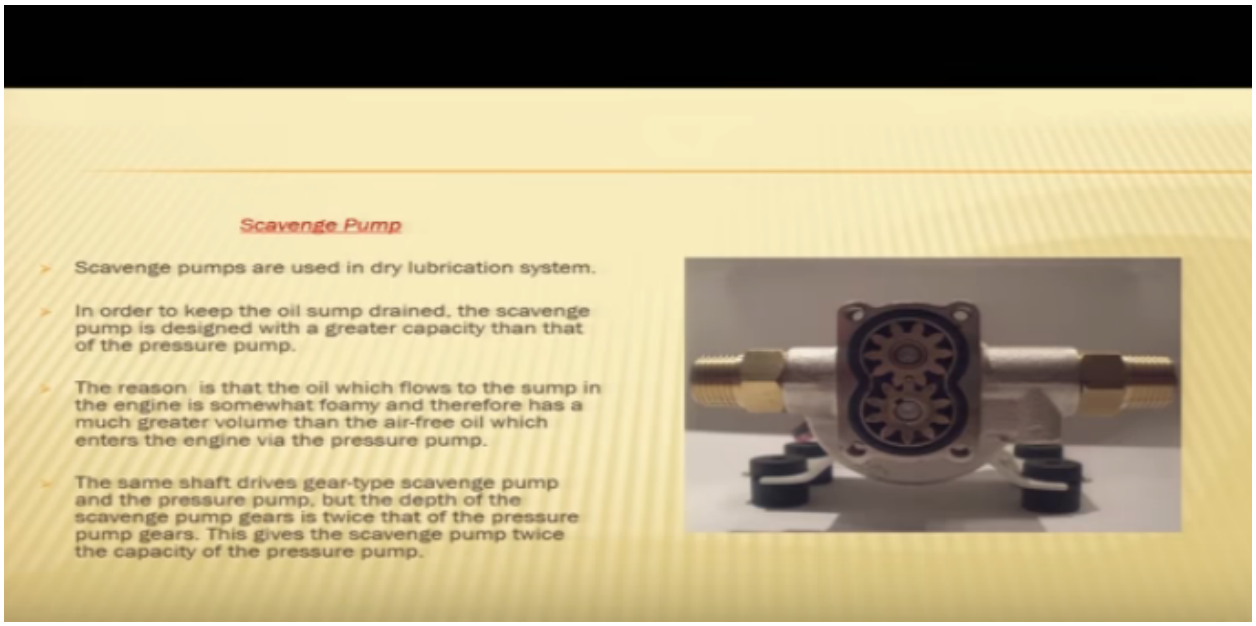

Another scavenge pump which is used in the dry sump lubrication system. We all know, we have seen earlier, that the scavenge pump is required, in a dry sump lubrication system scavenge pumps are used in dry lubrication system in order to keep the oil from drained, the scavenge pump is designed with a greater capacity than that of the pressure pump, Now, we all know, we have seen in our earlier slide, that the purpose of the scavenge pump is to bring back the oil from the, engine after lubrication back to the, oil storage tank. So in order to keep this oil some drain, the scavenge pump is designed, with a greater capacity than that of the pressure power reason is that the oil which flows to the sump in the engine, is somewhat foaming and therefore has a much greater volume than the air- free oil, which enters the engine why are the pressure pump. Now, the oil which flows to the sump is mixed with air so, it becomes foaming and the volume increases, so the volume of the oil which comes back to the sump after lubrication, which comes back to the crankcase after lubrication, is more than the oil which enters, the engine pump so we need to bring, more volume of oil, from the crankcase to the oil tank so, for this purpose you need a greater capacity of scavenge pump, the same shaft drives the gear type scavenge pump and the pressure pump. So, the same shaft is driving the pressure pump as well as the scavenge pump but the depth of, the scavenge pump gears is twice that all the pressure pump gears. So, we have just seen, why we need the scavenge pump of a greater capacity as compared to the pressure pump so, both the pumps the pressure pump and the scavenge pump they are being operated on the same shaft but, the depth, of the scavenge pump gears is twice, that of the pressure pump gears. This gives the scavenge pump twice, the capacity of the pressure pump so thus because you have, the scavenge pump gears of more depth, the scavenge pumps twice the capacity of the pressure pump.

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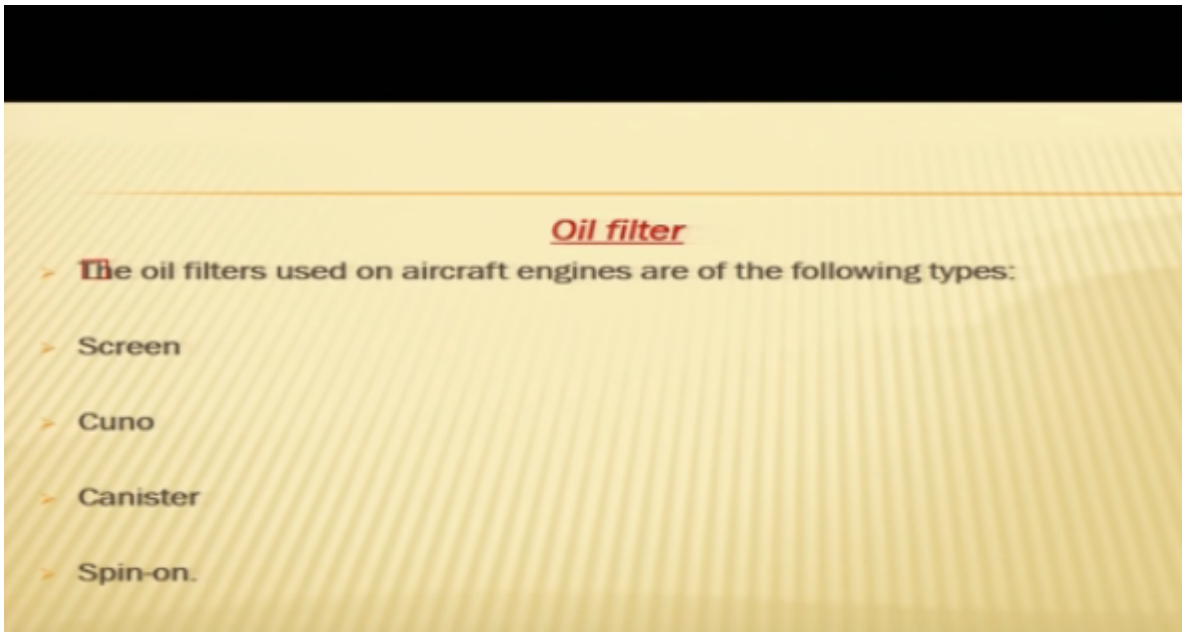

Now, to oil filter, oil filter is a very important component in the oil system. It is, a filter we know, what is the purpose of a filter it is to filter out, unwanted impurities, so the oil filters they are also of various types, screen filter, cuno filter, canister, spread on. So, these are the types of filters used.

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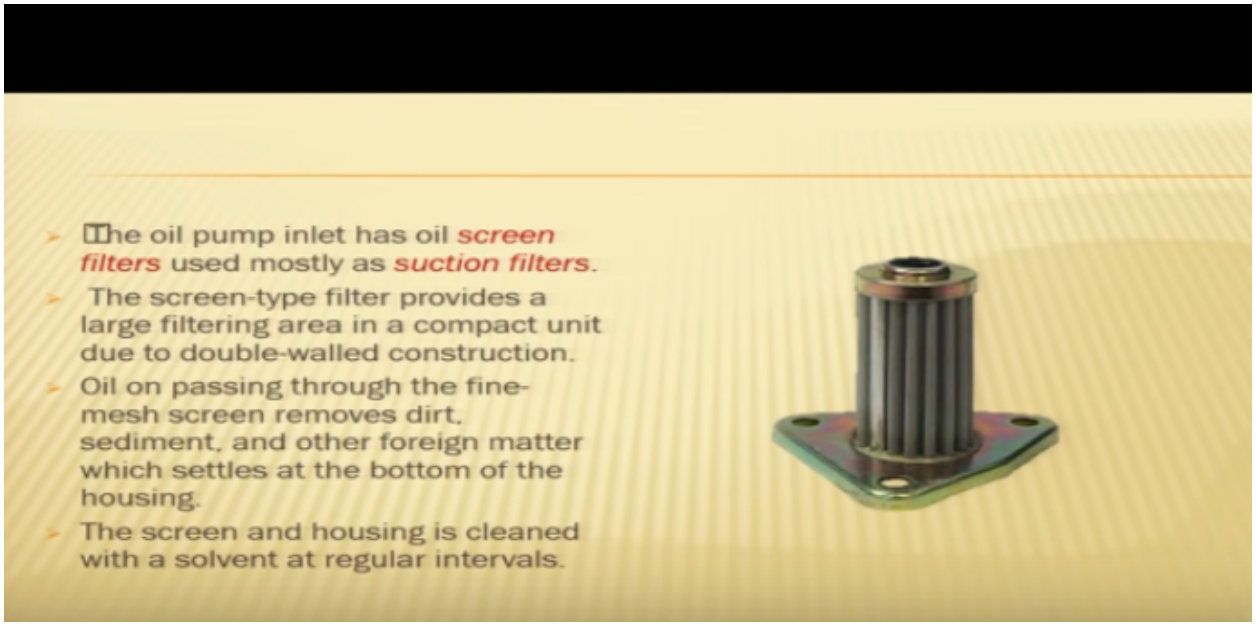

The oil pump Inlet has, oil screen filters used mostly as suction filters. So, in our video we will see that how is the, oil screen filter and it is acting as a suction filter so, the oil pump Inlet they generally have the oil screen filters which are mostly used as suction filters, in the figure you can see, one type of oil screen filter, the screen type filter provides a large filtering area in a compact unit due to a double walled construction . So, this is screen type filter. This provides a large filtering, in a compact unit, it has housed in a compact unit and it provides a large filtering area, due to a double walled construction. Oil on passing through the fine mesh screen removes dirt, sediment and other foreign matter which settles, at the bottom of the housing. So, this filtered through this oil screen filter and it removes dirt, sediment and other foreign matter at the bottom of the housing. The screen and housing is cleaned with a solvent at regular intervals. So, in our maintenance at regular intervals, we are supposed to please, clean the screen and the housing with a solvent.

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The Cuno, oil filter is often not used on modern aircrafts. A canister housing filter has a replaceable, filter element. So, you can see in the figure, there is a replaceable filter element this is your filter element you can see here, this canister housing ,it does the canister here this is a canister housing ,you can see this is case housing or canister and this is your filter element it is, our replaceable filter element you can see here, replaceable filter element this has got various other things rubber gasket here, then it has a cover plate, another rubber gasket nylon nut, you can see another copper gasket and hexagonal head screw. So, many things in this spectra assembly but, the important thing this filter element this is a replaceable filter element. The filter element is designed, with a corrugated strong steel center tube. So this, this has a strong steel center tube you can see this, this is your strong steel center tube, the filter provides excellent filtration because the oil flows through many layers of locked-in fibers. Now, this filter this provides

excellent filtration, because the oil flows through many layers of locked in fibers. So, this was a canister filter and Cuno oil filters are not, used on modern aircrafts.

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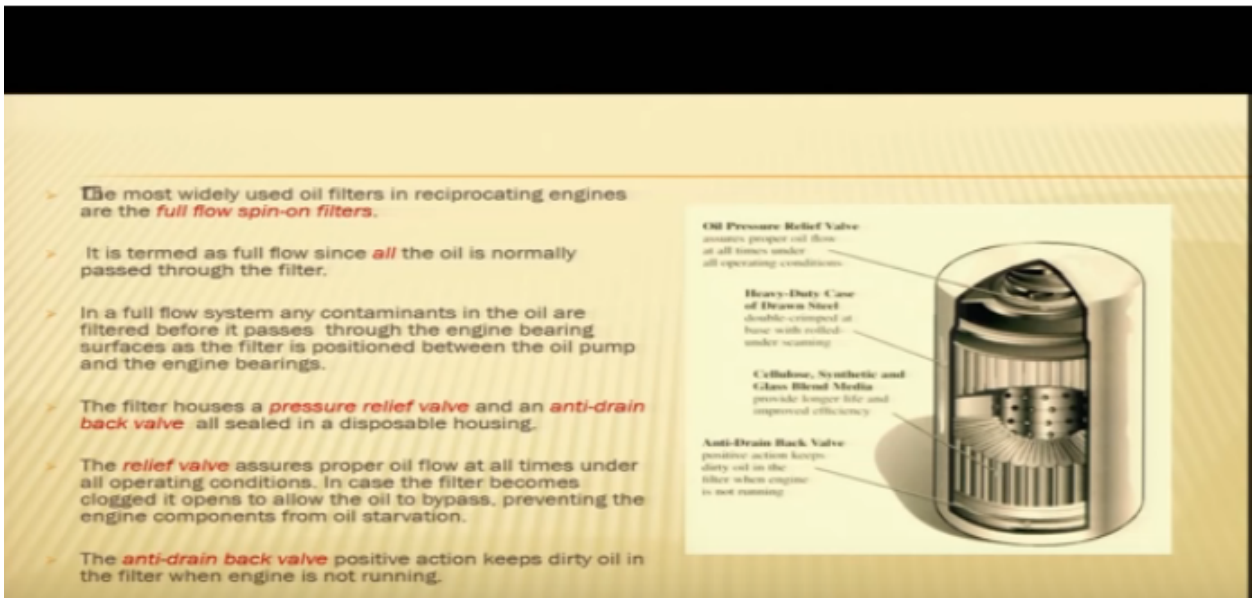

Coming to another type of filter, we have the full flow spin-on filter. You can see in the figure, it is the most widely used filter in reciprocating engines, the full Pro spin on filter, it is termed as full flow since all the oil is normally passed through the filter. So, it is called as, a ‘Full flow Filter’. Because, all the oil is, being passed through the filter in a full flow system, any contaminants in the oil are filtered, before it passes through the engine bearing, surfaces as the filter is positioned between the oil pump and the ancient bearings. Now, since the filter is positioned between the oil pump and the engine bearings it filters out, all the contaminants in the oil before it passes through the engine bearing surfaces, the filter houses a pressure relief valve, and an, anti drain back valve, all sealed in a disposable housing. So, you see in the figure this is your disposable filter housing, inside you have a filter element you can see this ,this is a filter element and this is, housed in a disposable housing it has, a pressure relief valve, here you can see there is a pressure relief valve, on top and an anti drain back valve, at the bottom. So, all this thing this is, housed in a disposable housing the purpose of the relief valve, it assures proper oil flow at all times, under all operating conditions. So this relief valve, this provides oil flow at all times under all operating conditions, in case the filter becomes clogged, it opens to allow the, oil to bypass, preventing the engine components from oil starvation so, this relief valve, in case the filter becomes clocked, it opens and bypasses the oil, preventing the engine components from oil starvation. The anti drain back valve, positive action keeps the dirty oil, in the filter when engine is not running. So, in case when the engine is not running, the dirty oil, is kept inside the filter only it has not, rained back to the engine, with the help of this, anti drain back valve, this anti drain back valve, thus keeps the dirty oil in the filter, when the engine is not running, so this is a full flow spin on filter, this is most widely used filter and we will show you in the video, this kind of a filter.

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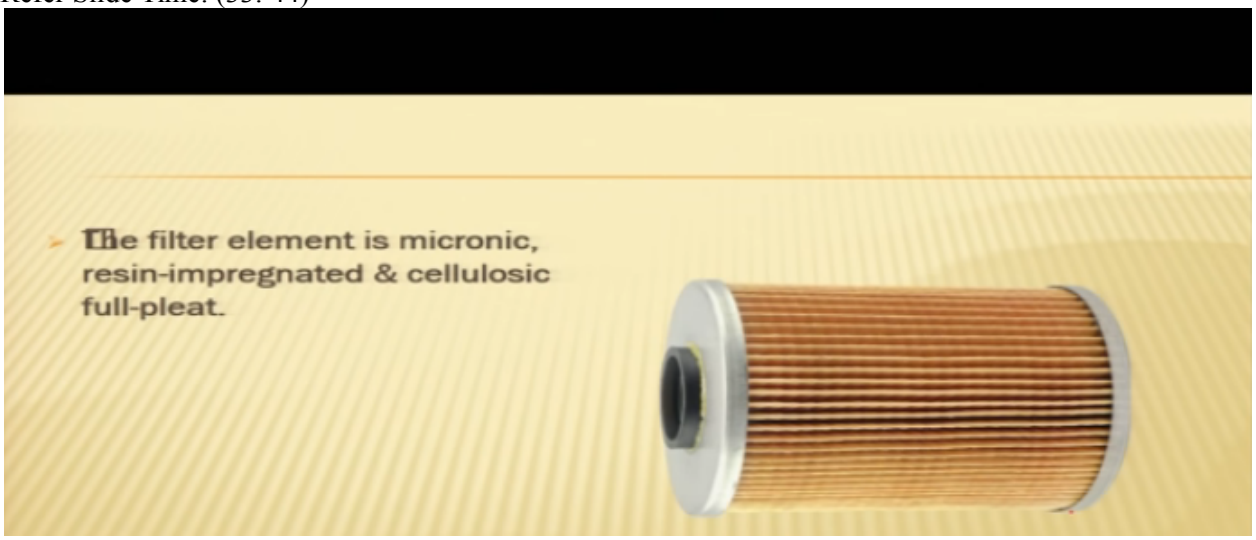

The filter element, it is moronic, resin impregnated and cellulosic full pleat. So, this is the filter element.

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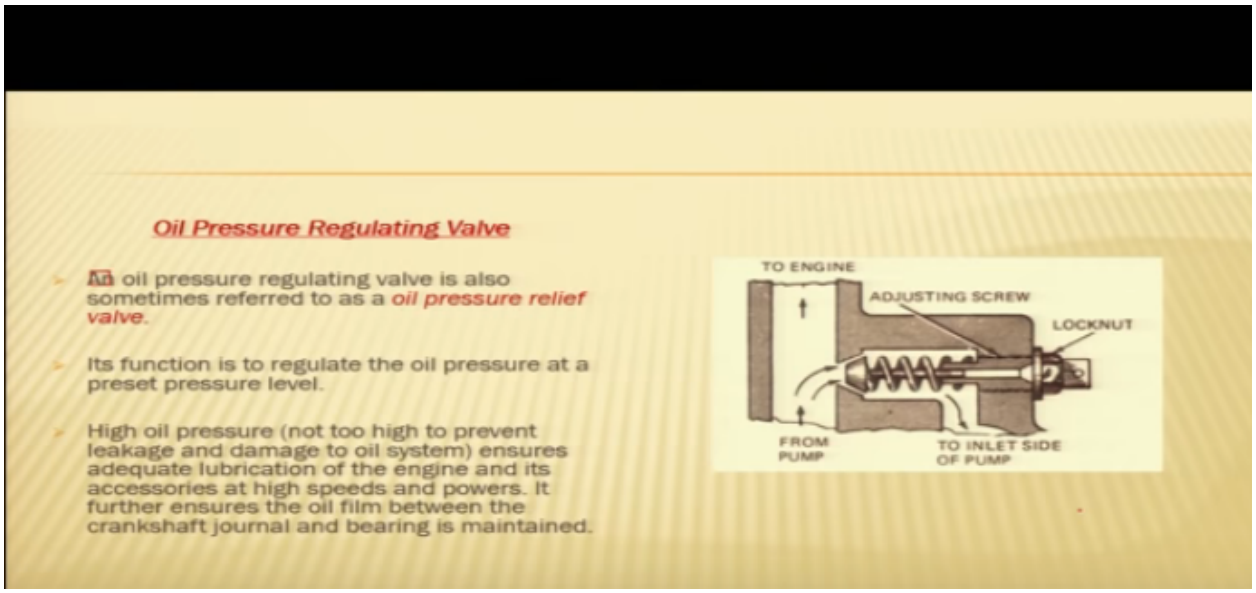

Next component, is the oil pressure regulating valve and oil pressure regulating valve, is also sometimes referred to as the oil pressure relief valve. Now, this as we have seen earlier, that the aircraft engine lubrication system, the oil needs to be pressurized, filtered and regulated, so pressurization was being

done, the oil was being pressurized with the help of an engine driven, oil pump, the filtering was being done with the help of a filter, the various types of filters, filters at various stages so, the oil is pressurized, is filtered and it has to be regulated also, so it is being regulated by means of, a oil pressure regulating valve or the oil pressure relief valve. So, the purpose of the oil pressure relief valve or the oil pressure regulating valve, is to regulate the pressure of oil in the engine lubrication system so, its function is to regulate the oil pressure, at a preset, pressure level. So, the pressure level is preset and the oil pressure regulating valve, will regulate the system pressure the lubrication system pressure at this preset level high, oil pressure not too high, to prevent leakage and damage to the oil system ensures, adequate lubrication of the engine and its accessories at high speeds and power. So the high, oil pressure in the lubrication system ensures, adequate lubrication of the engine and its accessories at high, speeds and powers, but the system pressure should not be that too high, to prevent leakage and damage to the oil system so, in case if the pressure is too high, there may be leakage and the oil there may be, damage to some components of the oil system so, the oil pressure has to be sufficiently high, but not too high, to provide leakage and damage to the oil system the high oil pressure will ensure adequate, lubrication of the engine and its accessories at high, speeds and powers it further ensures, the oil film between the crankshaft journal and bearing is maintained. So, high oil pressure will also ensure, that the oil film between the crankshaft journal and the bearing is maintained.