Lecture 27
Checklists for Aircraft Reciprocating Engine Maintenance

Hello, so far we have read about the, construction of the engine, reciprocating engine. We have seen different parts, in the engine. We have seen an engine in an open condition, in a dismantled condition. We have read about the fuel system, the different types of fuel used, the different components in the fuel, what are the inspections, we carry out in the fuel system. We read about the induction system, about the

exhaust system, the different components, in the induction system and the exhaust system. And the maintenance inspections, which are required to be carried out in these systems, apart from this, we also read about the exhaust system, the ignition system, in addition to this we have done an engine ground run. We saw the different checks, which are to be carried out, during the ground road and some of the maintenance, actions some of the maintenance schedules, which are required, at different intervals, as recommended by the manufacturer. We have seen, the daily inspection, we have seen the 50 hours of inspection, 100 hours of inspection, 200 hours of inspection, one year of inspection, on the engine on a reciprocating engine. Now there are a few points, general points, which we need to keep in mind while, we are maintaining an engine, in order to get ultimate output from your engine, in order to complete the engine life, it is very important that the some basic points, should be kept in mind, if we follow these points and we follow the instructions, recommended by the manufacturer, we are sure to get the complete life of an engine. And a trouble-free life of an engine. So, let us see here, what are these general points, some very basic points, some very points well, if we as a maintenance personnel keep it, in our mind and we follow, that then the engine, is most likely give to give us a trouble-free operation. So, let us see, what are these general points, in this small chair. We are showing you, some of the slides, some of the basic, point's different types of engines and what are the tests and inspections and what are the some, what are some basic points. We need to keep in our mind. So, let us see, what is it all about?

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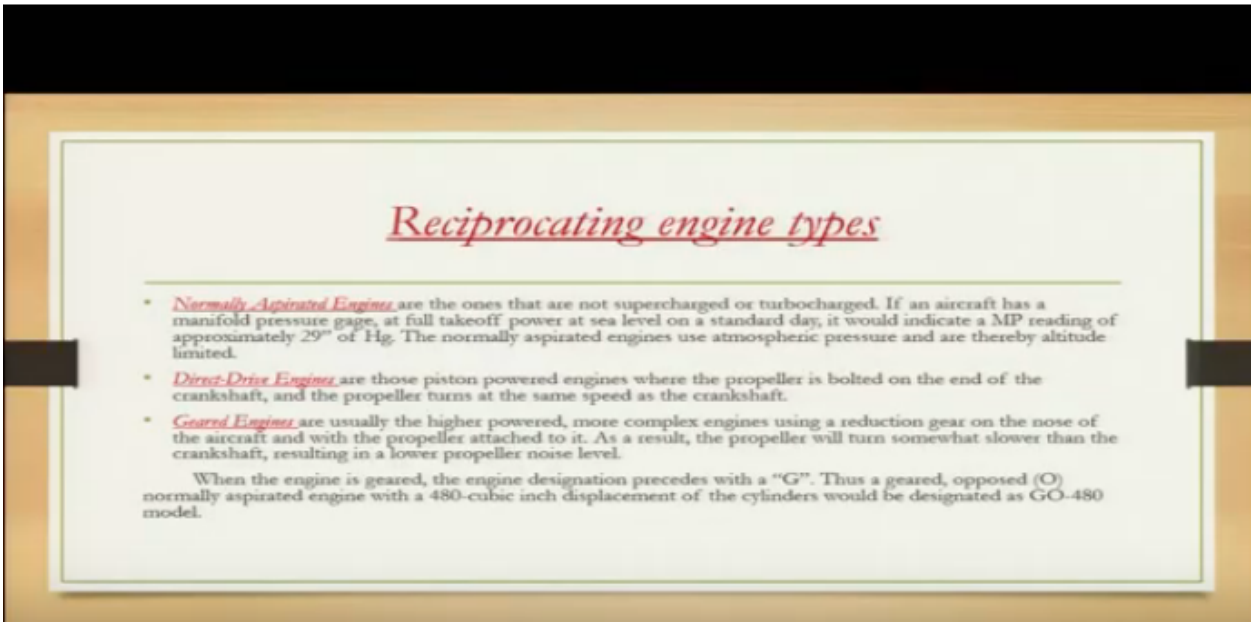

Now coming to the reciprocating engine types, various types of engines, during our course of the different lectures. We have come across, these terms, we have also mentioned about, these engines and let us see the em one by one, first is the normally aspirated engine, what is a normally as pirated engine? They are the ones that are not supercharged or turbocharged .We have read about the supercharged

engines, we have read about the, turbocharged engines. So, normally aspirated engines are the ones, which are not supercharged or turbocharged if an, aircraft has a manifold pressure gauge, at full take off power, at sea level, on a standard day. So, on a standard day, at sea level, at full takeoff power, it would indicate a manifold pressure, reading of approximately 29 inches of mercury. So, in case of normally aspirated engines, on a standard day, at sea level at full takeoff power, manifold pressure gauge will read 29 inches of mercury. The normally aspirated engines, use atmospheric pressure and thereby altitude limited. So, these normally aspirated engines, they are altitude limited, because they are using atmospheric pressure. Next is direct drive engines, these are engines, in which the propeller is bolted, on the end of the crankshaft.

So, on the direct drive engines, they are the best in powered engines, where the propeller is bolted, on the end of the crankshaft and the propeller turns at the same, speed as the crankshaft. Now what is a geared engine, geared engines are usually the higher powered, more complex engines, using a reduction gear on the nose of the aircraft. So, these geared engines they are higher power engines, more complex engines and they are using a reduction gear, on the nose of the aircraft and with the propeller attached to it. So, in between the propeller and the crankshaft, you have a reduction gear, attached as a result the propeller will turn somewhat slower, than the crankshaft, resulting in a lower propeller noise level. So, because of this reduction, gearing the propeller will turn at a slower, rpm fast compared to crankshaft and will also result in lower, propeller noise level, when the engine is geared, the engine designation precedes, with a g' now, now every engine, has been given a model number, it has it has been designated a model number, for example, any number in case of geared engines, will be preceded with a G, G stands for geared engine, thus a geared opposed normally, aspirated engine, with a 480 cubic inch displacement of the cylinders, would be designated as GO dashboard 8 0 model. So, G stands for, your geared engine, o is for a post or horizontally opposed engine and 4 8 zero is the 480 cubic inch displacement of the cylinder. So, this is how the engine model, is designated.

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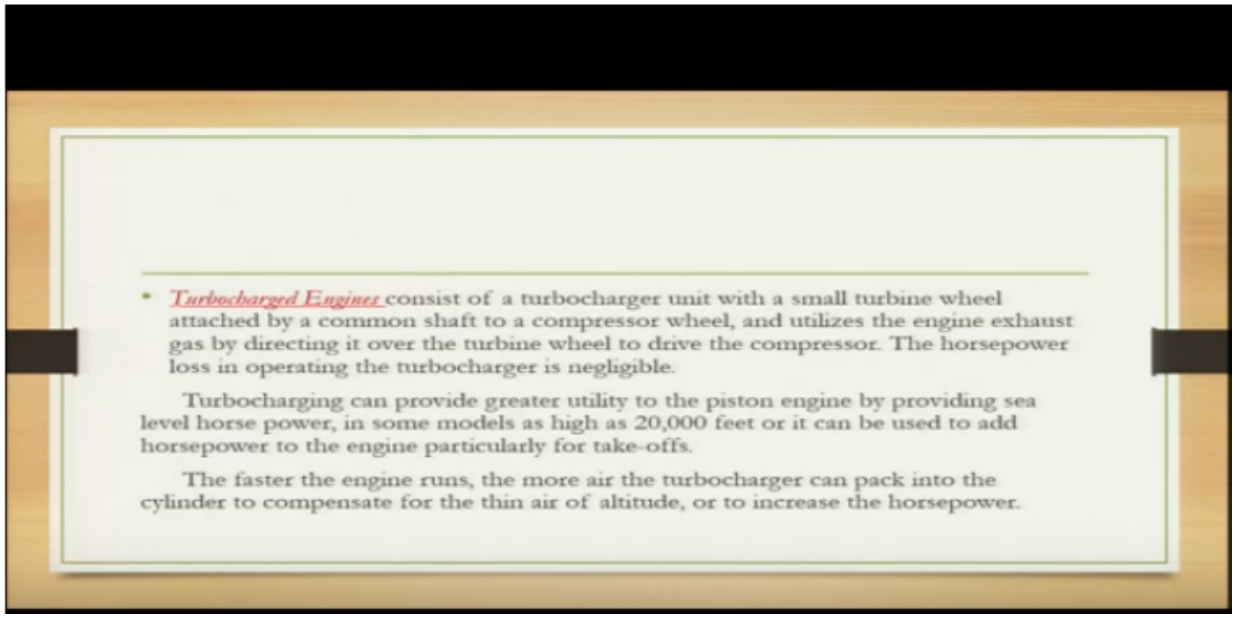

Next is your turbocharged engine, it consists of a turbocharger unit, with a small turbine wheel, attached by a common shaft to a compressor wheel. We have read earlier about turbocharged engines, just to brush up it is it consists of a turbocharger unit, with a small turbine wheel, attached by a common shaft, to a compressor wheel and utilizes the engine exhaust gas, by directing it over the turbine wheel, to drive the compressor. So, the exhaust gases are being driven, over the turbine wheel to turn drive the compressor, the horsepower loss in operating the turbocharger, is negligible turbocharging, can provide, greater utility to the piston engine by providing, sea-level horsepower, in some models, as high as twenty thousand feet or it can be used to add horsepower to the engine, particularly for takeoffs. So, turbocharged, ding will add power, to the engine especially for takeoffs and it can also provide sea level horsepower, at higher altitude, the faster the engine runs, the more air the turbocharger can pack into the cylinder, to compensate for the thin air of altitude or to increase the horsepower. So, the faster the engine runs, turbocharger will provide more power, into the cylinder to compensate for thin air, of altitude ,because we know that as, we go up as altitude increases, air thins down. So, in order to compensate, for the thinning of air at altitudes, turbocharger will provide, compressed air and it will increase the horsepower.

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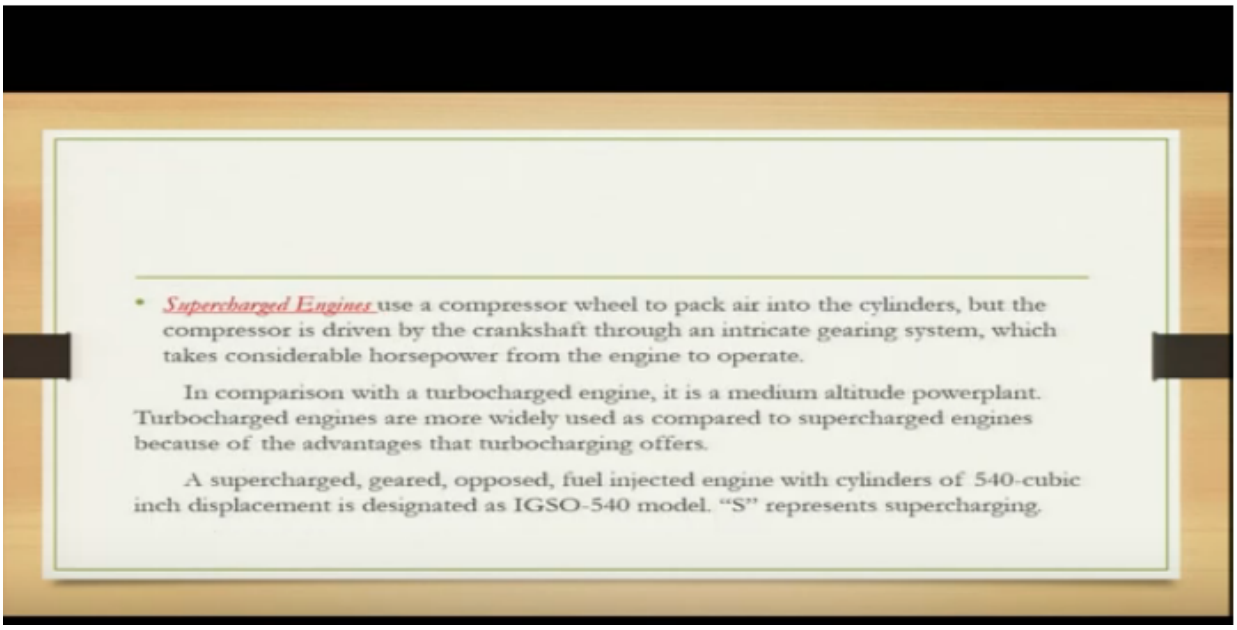

Next is your supercharged engine, now supercharged engines ,they use a compressor wheel, to pack air into the cylinders, these superchargers they are also, using a compressor wheel, to pack air into the cylinders, but the compressor is driven by the crankshaft, through an intricate gearing system. So, in this case the compressor, is being driven by the engine crankshaft, through a gearing system, which takes considerable horsepower from the engine to operate, in comparison with a turbocharged engine, it is a medium altitude powerplant. So, as compared to turbocharger, turbocharged engines, supercharged engine, is a medium altitude powerplant, turbocharged engines are more widely used, as compared to supercharged engines, because of the advantages that turbo charging offers. Now because turbo charging, turbo charges they have more number of advantages, as compared to supercharged engines. So, turbocharged engines are more widely used, in the industry, a supercharged geared opposite, opposed

fuel-injected engine with cylinders of 540 cubic inch displacement is designated as IGSO 540 model. So, I is for injected, fuel-injected engine, G is for geared engine. S is for supercharged engine. O is for horizontally or post and five four zero is the cubic inch displacement, of the cylinder and this is how it is designated as IGSO dash five four zero model. S represents supercharging. So, this was about the different types of engines, different types like normally aspirated engines, direct drive engines, geared engines turbocharged engines. So, much our engines different types of reciprocating engines. So, this was just to brush up, what we had read in our earlier lectures.

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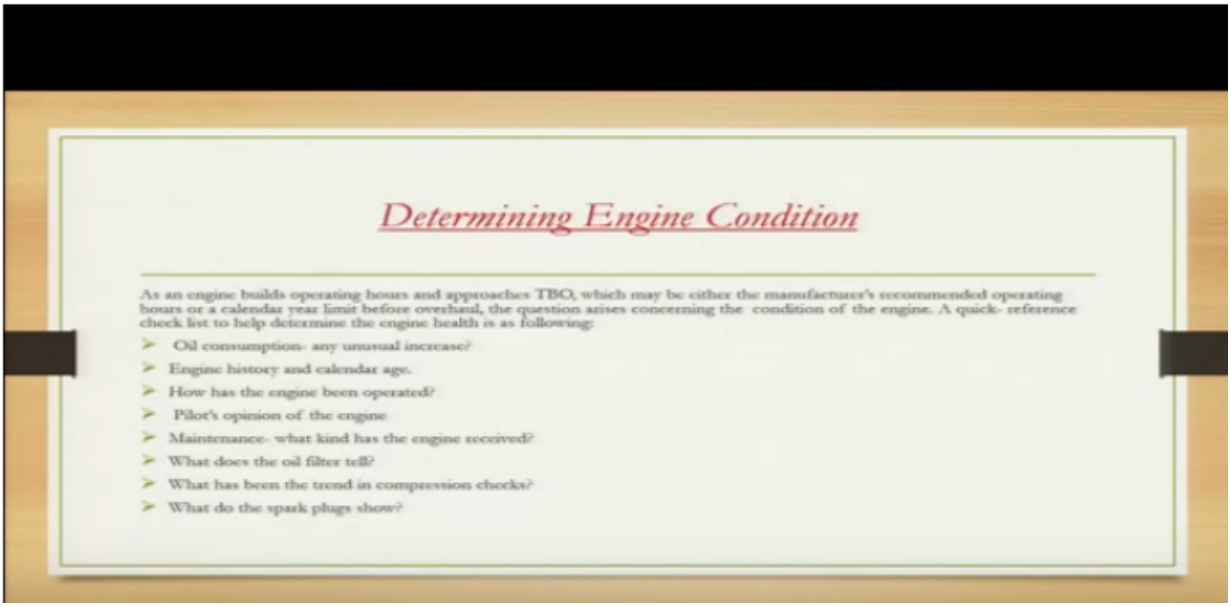

Now as the engine life, increases, as the number of hours, number of operating hours of the engine increases, the deterioration is bound to occur. And as the engine approaches, it's life, we as maintenance personnel and we as operators. We should keep a very close watch, on the engine and the help of the engine. So, what are the different points that basic points that will give, us an idea of the engine health, let us see what are these points? Now determining engine condition, as an engine builds operating us and approaches, TBO, which may be either the manufacturer's recommended operating hours or a calendar year limit before overhaul, the question arises concerning the condition of the engine. How the manufacturer has, fixed an engine life, on the basis of the operating us, as well as the calendar period. So, the life of the engine, on the basis of operating hours and calendar life should be closely monitored. And as it approaches its life, suppose the life is two thousand hours or twelve years, whichever is earlier and your engine is about, to complete two thousand hours, but the calendar period is say only five years, in that case also we need, to close watch the condition of the engine or the case maybe your, engine has just completed 500 hours, but your calendar period is approaching 12 years, in that condition also you need to keep a continuous watch on the health of the engine.

A quick reference checklist to help determine the engine health is a following. First is oil consumption, any unusual increase, we need to see, whether the engine oil consumption has increased or there is an unusual increase, engine history and calendar age, we need to consider the history of the engine, how the engine has performed, in the previous operating hours and what is the calendar age of the engine? How has the engine being operated? How the engine has been operated, pilots opinion of the engine, the pilots who are flying the engine, flying the aircraft, what is their opinion about the engine? Maintenance what kind has the engine received? Very important over the period of time how the engine has been maintained, whether it has been maintained, as per the manufacturer's recommendations, approved procedures and approved materials, have been used, what does the oil filter tell, very important we will see about this, what has been the trend in compression checks. Compression check, we have seen in our previous, lecture how the compression check is carried out, why is it carried out and what is the trend, in the compression checks. We need to keep a watch and what do the spark plugs show. And also the condition of the spark plugs. So, these general points, they can tell us about the health of the engine, oil consumption engine history and calendar age, how the engine has been operated, pilots opinion of the engine maintenance what kind of engine, what kind has the engine received? What does the oil filter tell compression check trends? And the spark plugs condition. So, these general points, they can tell us about the condition of the engine.

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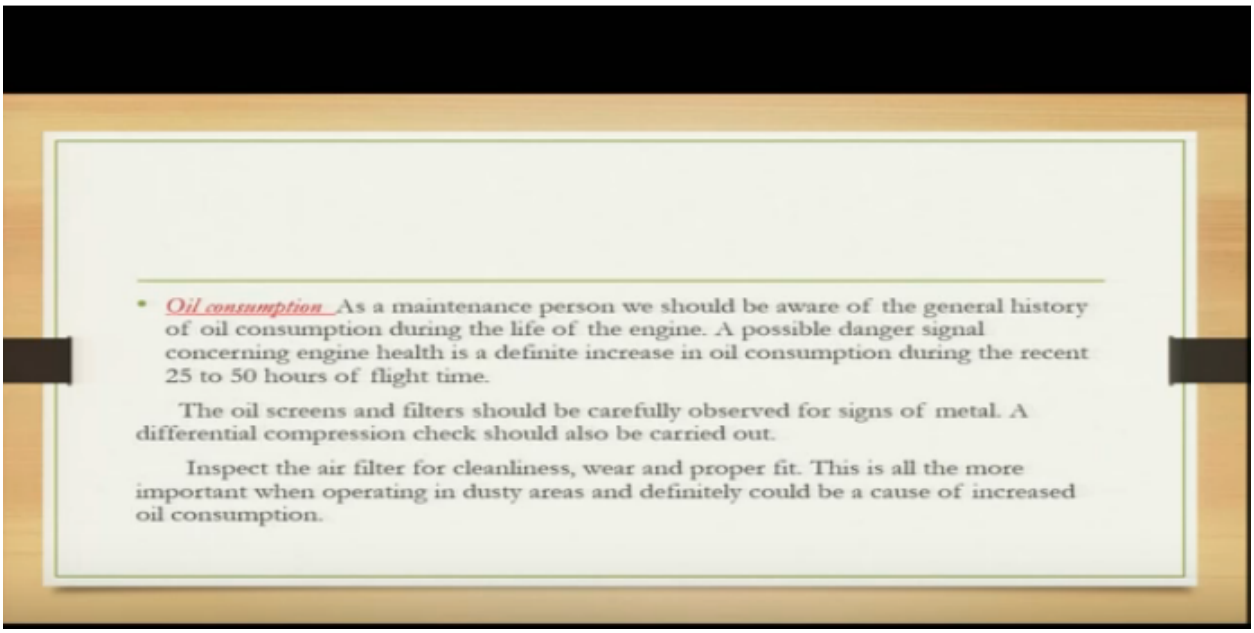

Let us see one by one, oil consumption. First is oil consumption, as a maintenance person we should be aware of general, history of oil consumption, during the life of the engine. Yes because since, we are maintaining the aircraft, we are maintaining the N and an engine. We should be aware, of the general history, how the oil has been consumed by this engine, in case it has been within the limits, it has been normal throughout the, life or it has been erratic or it has off late the oil consumption has increased. So, we should know, the trend of oil consumption, a possible danger signal, concerning engine health, is a definite increase, in oil consumption during the recent, 25, 250 hours of flight time. So, in case if the oil

consumption, has very recently increased in the last 25 to 50 hours ,if it has drastically increased, then that is a possible danger sign and we need to keep a proper watch on it. And we need to take corrective actions, as recommended by the manufacturer, the oil screens and filters, should be carefully observed for signs of metal. So, the oil filters and the screens, they should be very closely washed, they should be observed for any signs of metal, to see whether there is anywhere in the internal, construction of the engine, a differential compression, check should also be carried out. So, in case if you have seen that the oil consumption has, drastically increased, in the last 25 to 50 hours, we need to check the oil filters, we need to carry out a differential compression check, inspect the air filter for cleanliness where and proper fit. So, apart from checking the oil filter and doing the compression check, we also need to inspect the air filter, for cleanliness wear and proper fit. This is all the more important, when operating in dusty areas and definitely could be a cause of increased oil consumption. Now in case if your aircraft is operating, in dusty and sandy conditions, in that case the engine is getting, more dirt inside and in case if your filter, is clogged or your filter, is damaged that means more dirt is going inside the cylinder, your engine is getting unfiltered air and that can be a cause of oil consumption. So, we increase oil consumption, it has a very important thing, we need to keep a watch on the consumption, of the engine, during the entire life of the engine and that oil consumption trends, we need to see and in case if there is a drastic increase of oil consumption, in the recent twenty five to fifty hours. That should be seen and certain checks should be carried out, oil screen and filters should be checked compression, check should be carried out. And air filter, should be cleaned or replaced as the case may be.

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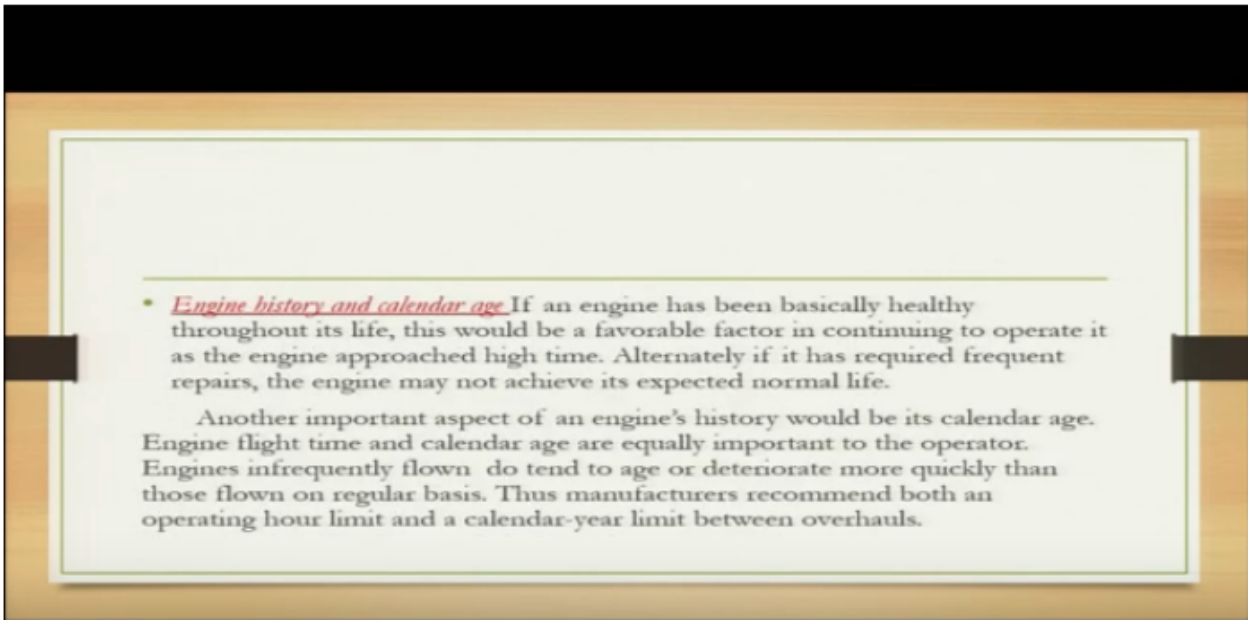

Next point, to see the engine history and calendar age. We should see what the engine history is and what is the calendar age? If an engine has been basically, healthy throughout its life, this would be a favourable factor in continuing to operate, it as the engine approached high time. Now in case if the engine has

operated, satisfactorily throughout its life. And there is no abnormal, indication then we should be satisfied and it is most likely that the engine will complete its life alternately, if it has required frequent repairs, the engine may not achieve its expected normal life. Now in case, if the engine or its operation operating life, has required frequent repairs, frequent maintenance than in that case it is not likely that engine will achieve, its expected not normal life. Another important aspect of an engine's history would be its calendar age, engine flight time and calendar age are equally important to the operator. So, the calendar period, the calendar life of the engine, is also very important and engines infrequently, flown do tend to age or deteriorate more quickly, than low slowed on regular basis. So, a very important point we will cover this point in detail, in our further slides that any engine, which is not being operated frequent, frequently is likely to deteriorate more quickly, than those flown on regular basis, thus manufacturers recommend both an operating hour limit and a calendar error limit between overhauls. So, that is why the manufacturers they will recommend the engine life, on the basis of the operating hours as well as the calendar period, for example the life of the engine of Cessna 2:06 what aircraft, we have been watching in our videos, is $2,000 12 years whichever is earlier. So, that means 2,000 of operating hours or twelve years of calendar period, whichever is earlier operation.

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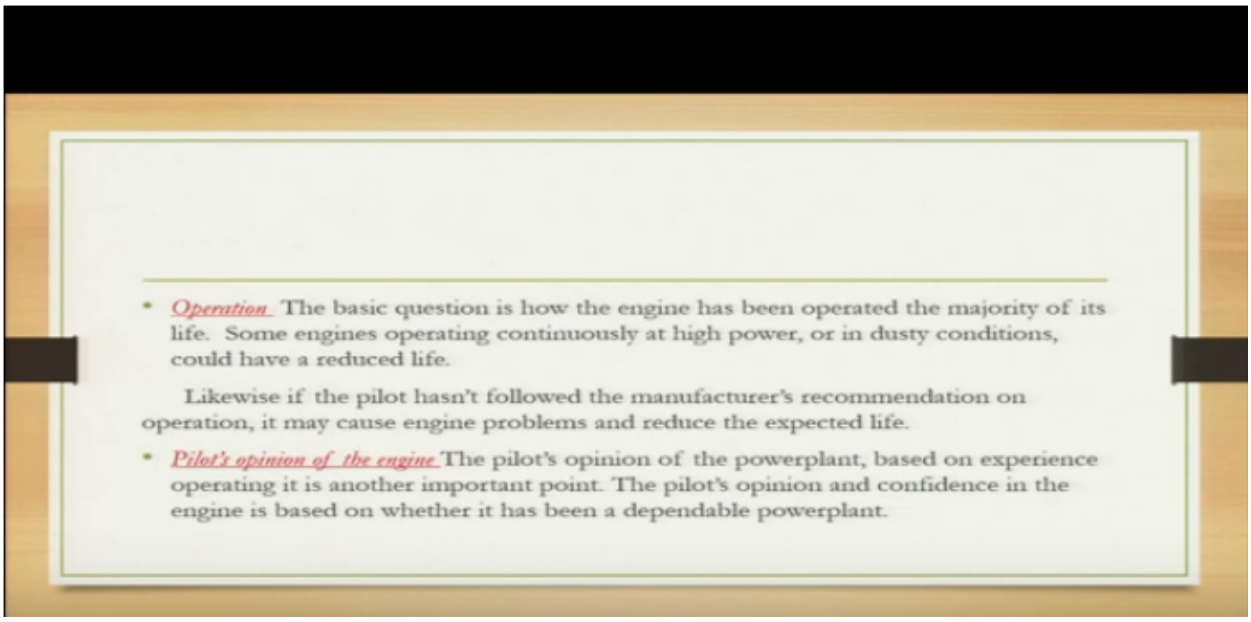

The basic question is how the engine has been operated, the majority of its life. Now how the engine has been operated, how the pilots have handled this engine this that is also a very important point, to be considered while analysing the health of the engine, some engines operate continuously at high power or in dusty conditions, could have a reduced life. Now it depends where your engine has operated, in case if it has been operated in dusty conditions or in case it has been operated continuously, at high power

operations, then in that case also your engine could have a reduced life. So, very important how the engine has operated, during its, service life likewise, if the pilot hasn't followed the manufacturer's recommendation, on operation, it may cause engine problems and reduce the expected life. So, very important point also, the pilots, the operators, they need to follow, the instructions by the manufacturers and all these instructions are mentioned, in the pilots operating handbook and all the instructions the manufacturers recommendation, need to be followed and in case if the pilot has not followed, these recommendations, then the engine will have faced problems and will and is expected to have, reduced life. Next very important point is the pilot's opinion of the engine, now the person who is operating, who is flying the aircraft? Who is handling the engine? Who is handling the machine? What is what his feeling about the engine? That in that opinion of that person is also very important, whether during the course of operation, he is comfortable, about the engine whether he is confident about that engine or not that opinion is also very, very important. The pilot's opinion of the power plant, based on experience, operating it is another important point, the pilot's opinion and confidence in the engine is based on, whether it has been a dependable power plant. So, over the period of time and the power when the pilot is operating an engine, he develops confidence, in that machine and whether during the entire service life, the person has felt confident about that machine or not that opinion is very important, while ascertaining the health of the engine.

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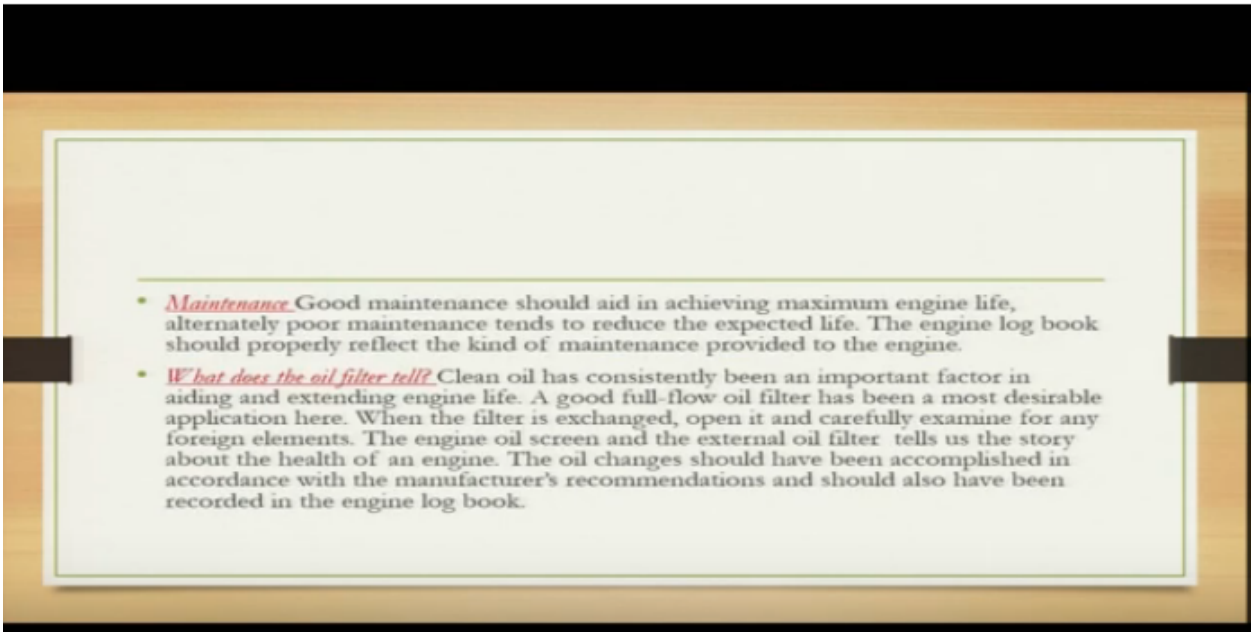

Next is the maintenance a very, very critical point, very important point, good maintenance should aid in achieving maximum engine life, alternately poor maintenance, tends to reduce the expected life. Now this is a very general point, we all know that if we maintain, a machine a good maintenance is carried out, it is going to achieve maximum life and in case of poor maintenance, it will reduce the expected life, the engine logbook should properly reflect the kind of maintenance, provided to the engine. Now whatever maintenance actions have been carried out, on the engine, they have to be entered in the engine logbook and these engine logbooks, they are the legal documents and they are the proof, but that whether the

machine has been maintained properly or not. So, these records should also be viewed, to ascertain the health of the engine. Now coming to the other maintenance, aspects let us see, what does the oil filter tell? So, as we know that oil is a very important thing, it is the lifeline of an engine. And the oil filters they are very, very important components of an engine. So, let us see what does the oil filter tell? Clean oil has consistently been an important factor, in aiding and extending engine life. So, clean oil that is very important for an engine, to give it a full life a good full flow oil filter, has been a most desirable application here. When the filter is exchanged open it and carefully examine for any foreign elements. Now when this filter, is replaced when we remove the old filter, put a new filter, the old filter, the old oil filter should be opened and the element inside should be carefully examined, for any foreign elements. The engine oil screen and external oil filter, tell us the story about the help of an engine. So, the condition of the filter element, tells us the story, about the health of an engine, in case if you observe any particles metal particles or that means that is an indication, somewhere is happening inside your engine and you need to take corrective action. The oil changes should have been, accomplished in accordance with the manufacturer's recommendations and should also have been recorded in the engine logbook, engine oil replacement, generally the manufacturers they say 50 hours or four months whichever is earlier 50 hours, of operating time or for calendar months, whichever is earlier. So, the engine oil change, is a very important point, to be considered while, maintaining an engine, we should be very strict about it and the engine oil should be replaced, strictly at 50 hours or four months, whichever is earlier, in case if we follow this, we are we should be comfortable, about the engine.

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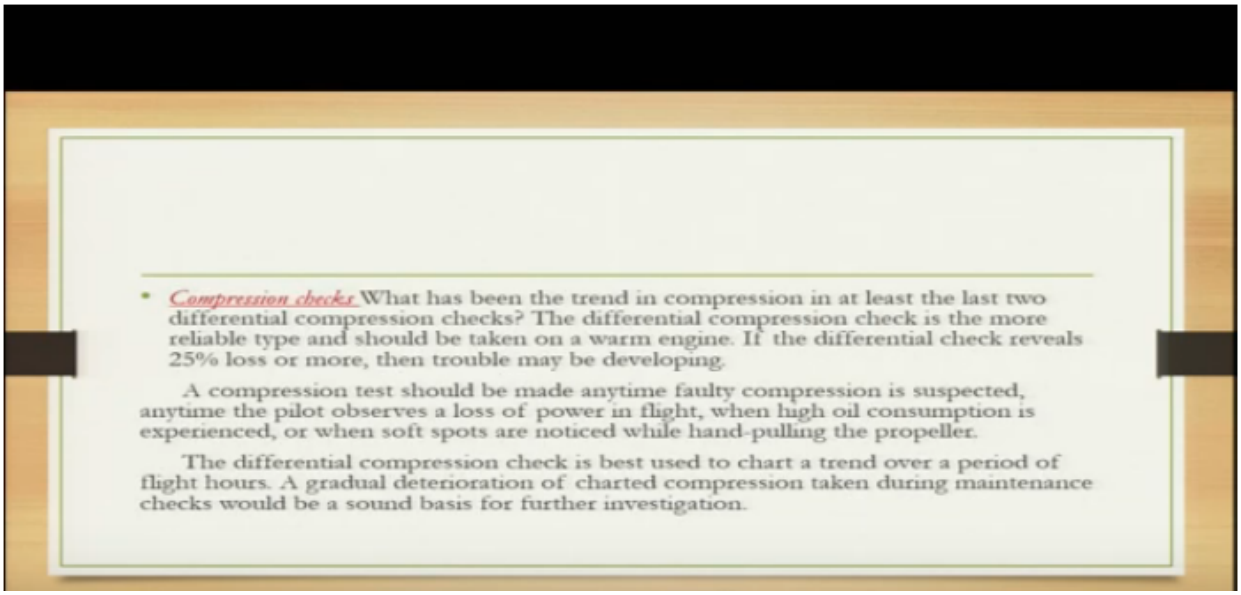

Next is the compression check. We have seen in our previous lecture how, we carry out a compression check, now let us see why it is important and this compression check, is also a very important test, to see the health of the engine. What has been the trend in compression in at least the last two differential compression checks? So, in the last two compression checks, what readings we have observed that should be checked that should be observed, whether there is a drastic change in the compression check readings or not, the differential compression check is the more reliable type and should be taken on a warm engine. Yes we know that it has to be taken on a warm engine, if the differential check reveals 25% loss or more

than trouble may be developing. Now in case if you are observing a loss of 25% or more that indicates that some is about to come, a compression test should be made anytime, faulty compression is suspected, any time pilot observes a loss of power in flight, when high oil consumption is experienced or when soft spots are noticed while hand pulling the propeller. So, these are the occasions when we are required to carry out a compression test, whenever you observe a faulty compression or you suspect a faulty compression, any time your pilot is observing, a loss of power in flight, whenever you observe high oil consumption or when you are turning the propeller, by hand you experience, some soft spots. So, in these conditions, you are required to carry out, a compression check apart from these points compression check, is also required to be carried out, at every hundred hours of operation and every hundred hours of schedule, we are required to carry out, a compression check of the engine, to ascertain the health of the engine. The differential compression check is best used to chart a trend, over a period of flight as a gradual deterioration, of charted compression, taken during maintenance checks would be a sound basis for further investigation. So, whatever readings are being observed, in the compression check, we need to record them and we need to, watch and analyze these readings, very close very closely to ascertain, the health of the engine or a gradual deterioration, of the engine and these readings should, be a sound basis for further investigation.

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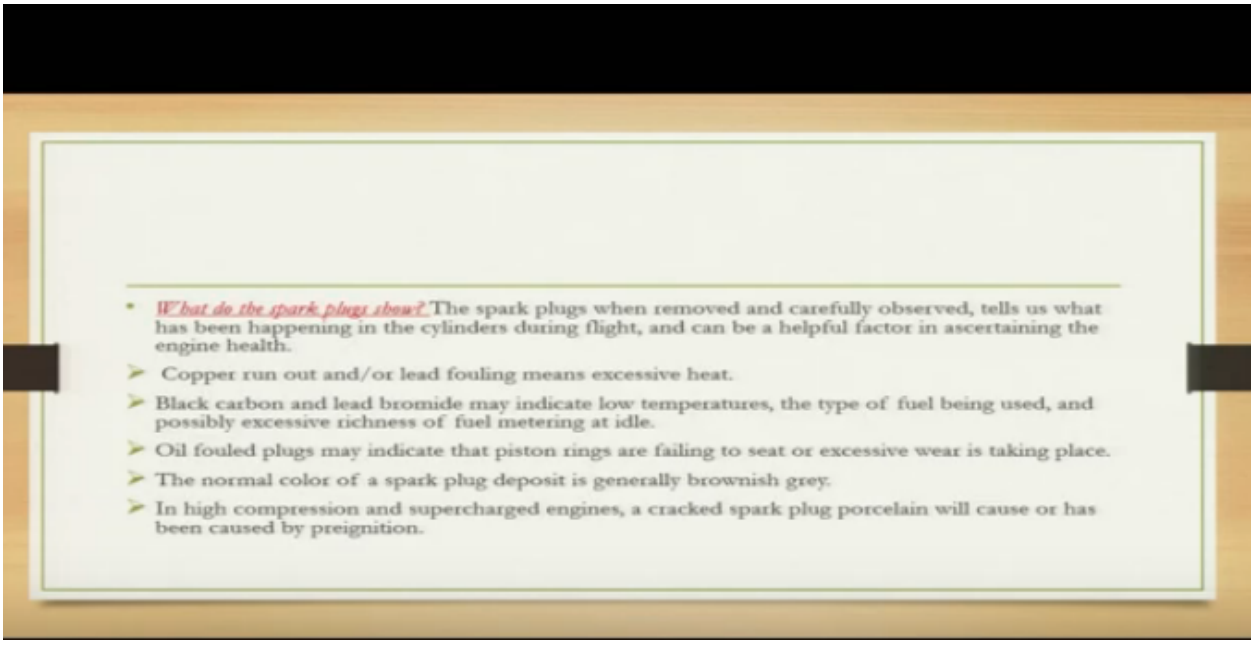

Next is your spark plug. Now spark plugs also tell us, lot of things about the engine. And these spark plugs up should also be, closely observed and they should be analysed. The spark plugs when removed and carefully observed tells us, what has been happening in the cylinders during flight and can be a helpful factor, in ascertaining the engine health. So, these spark plugs, they also tell us what is happening in the flight and they can also tell us about the engine health, in case if you observe, copper run out and or lead fouling it means excessive heat. This is the first indication if in case copper run out or lead fouling is observed that means excessive heat, in case black carbon and lead bromide may indicate, low

temperatures, in case if you see black carbon or lead bromide on the, plugs then that indicates, low temperatures the type of fuel being used and possibly excessive richness of the fuel metering at idle. So, black carbon or lead bromide, that indicates that your mixture is on the richer side, the type of fuel being used and also may indicate low temperatures. Now in case if the plugs show us, oil fouling that indicates that your piston rings are failing, to seat or excessive beer is taking place. Now if the plugs are showing you, we fouling that means your rings are not sitting properly or there is excessive wear on the piston rings, the normal color of a spark plug, deposit is generally brownish gray, in case if you observe a brownish gray color of deposit that on the spark plug, that indicates, that it is of normal color and which it is a normal operation. In high compression and supercharged engines, cracked spark plug porcelain, will cause or has been caused by pre-ignition. So, in case of high compression and supercharged engines, if your spark plug porcelain has cracked, then it is because of preignition or it may lead to preignition.

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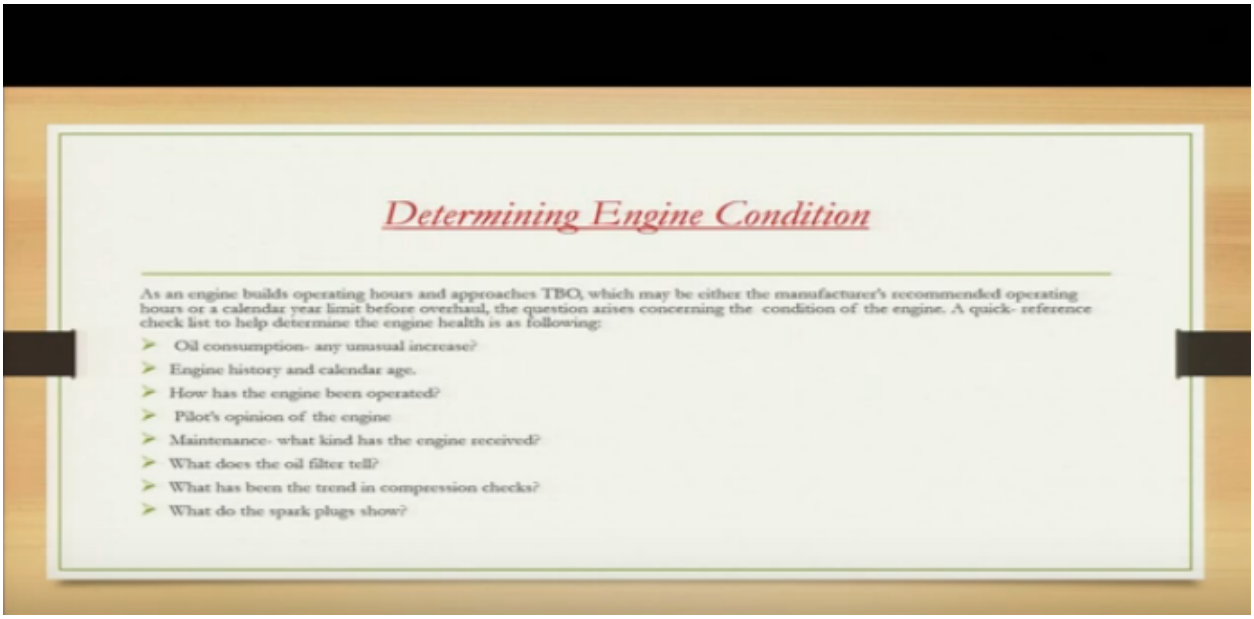

So, these were some of the points to, ascertain the health, of the engine and we should continuously keep a watch on the engine health, while we are maintaining, we should continuously analyse all these points, the oil consumption engine history, how the engine is being operated, what is the pilots opinion, of the engine what kind of maintenance is being done? What are the oil filters telling us? What has been the trend in the compression checks? And how the what are the spark plugs telling us? So, these are in general points to be observed, while maintaining an engine to ascertain the health of the engine.

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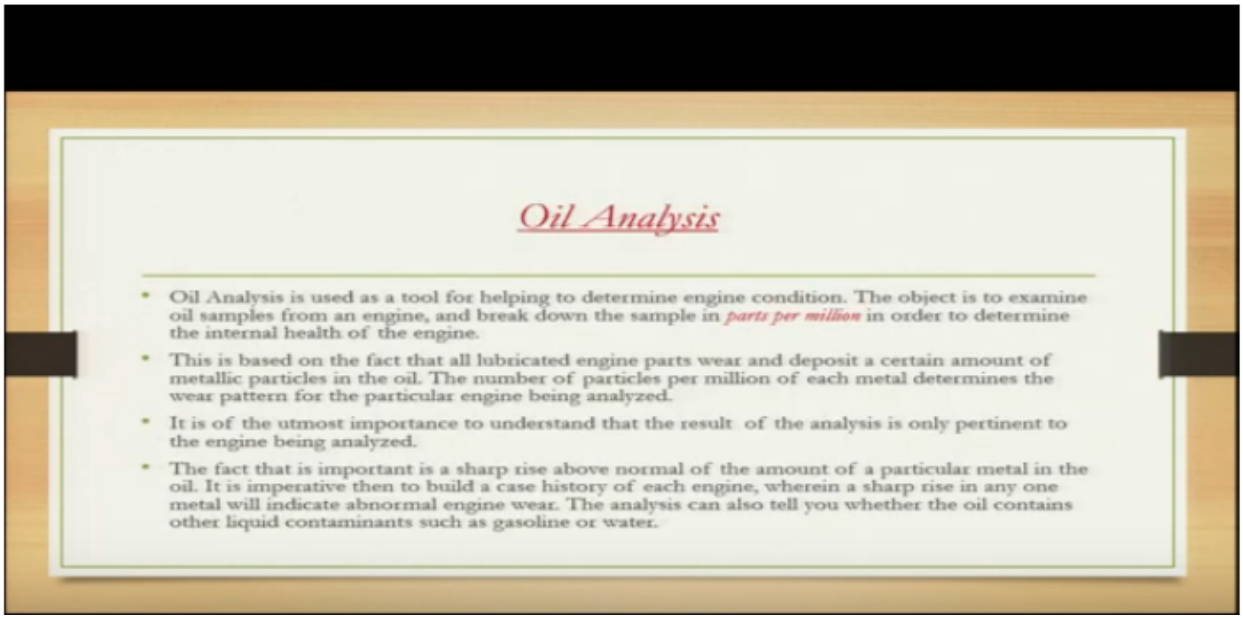

Another very important tool, to observe to be observed and to ascertain the health of the engine is oil analysis, whatever oil samples we are taking, we need to analyze, these oil samples and we have to carry out an oil analysis, to understand the health of the engine, oil analysis is used as a tool for helping to determine engine condition, the object is to examine oil samples, from an engine and break down, the sample in parts per million in order to determine the internal health of the engine. So, the internal health of the engine can also be determined, by taking the oil samples from the engine, by testing these samples and these samples they are broken down, in parts per million, to determine the internal health of the engine. This is based on the fact that all lubricated engine parts, where and deposit a certain amount of metallic particles in the oil. So, the basis of this analysis is that all the lubricated engine parts, will wear and they will deposit, a certain amount of metallic particles in the oil, the number of particles per million, of each metal determines, the wear pattern for the particular engine being analysed. It is of the utmost importance, to understand that the result of the analysis is only pertinent to the engine, being analysed. So, very important we need to understand that, the report is for that specific engine and whatever analysis is being made, is for that specific engine. The fact that is important is a sharp rise, above normal of the amount of a particular metal in the oil. So, in case if there is a sharp rise, in the amount of a particular metal, that is to be observed, it is imperative then to build a case history of each engine we're in a sharp rise in one metal will indicate abnormal, engine wear. So, we need to observe the samples, we need to have data of that engine, of all the samples I need to observe that how that particular metal wear, has increased. The analysis can also tell you, whether the oil contains other liquid contaminants such as gasoline or water. So, this analysis can also tell you, whether the samples they have gasoline or water also in it.

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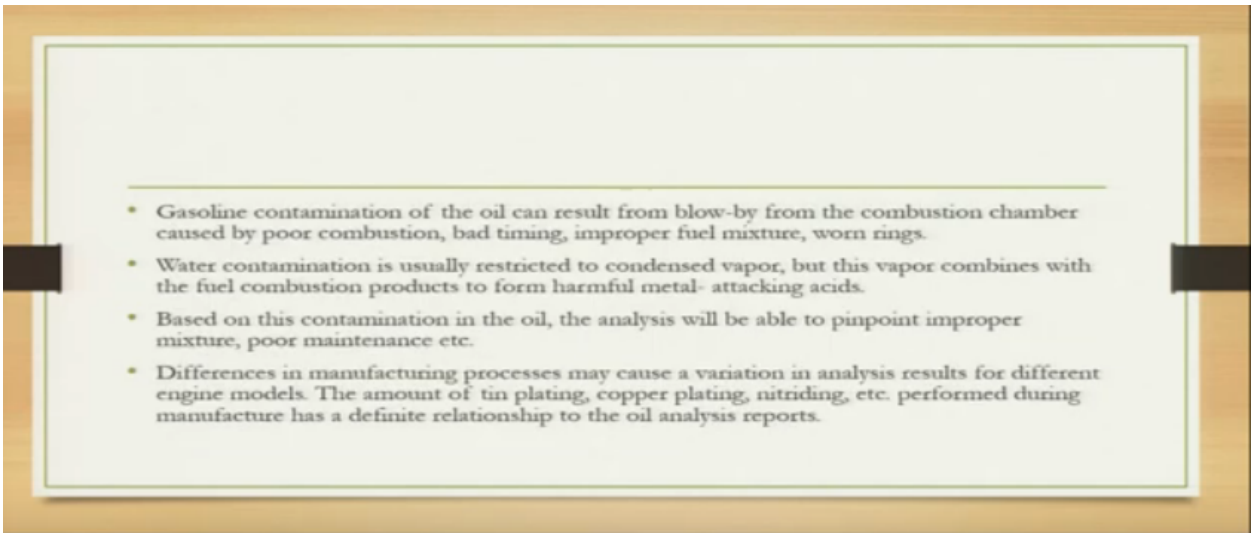

gasoline contamination of the oil canresult from blow-by, from the combustion chamber, caused by poor combustion, backtime bring, in proper fuel make sure wornrings. So, this gasoline contamination, this can occur, because of these reasons blow by from the combustion chamber, workon combustion, back typing, improper fuel mixture, of worn rings. Water condom, contamination is usually restricted to condensed vapour, but this, vapour combines with the fuel, combustion products, toform harmful, metal attacking assets. So, this is very important, in case if thereis water contamination, it is mainly dueto condensed vapour, but this, vapour will combine with the fuel combustion products, to form harmful metal attackingacids. Based on this contamination in theoil, the analysis will be able to pinpoint, improper mixture, poor maintenance etc. So, this analysis will help us, intelling, whether your, you are operating,on an improper mixture or poor maintenance is being done, differences in manufacturing processes may cause avariation in analysis results for different engine models, the amount oftin plating, copper plating, nitriding etcetera, performed during manufacture has a definite relationship, to the oilanalysis reports. So, different manufacturing techniques, processes areused and because, of these difference, different techniques, different processes, the and there will be a variation in analysis results and it all depends among the upon, the amount of plating: that is done, on these, components during manufacture.So, we have to, take this also, into consideration, when, we prepare these oil analysis reports.

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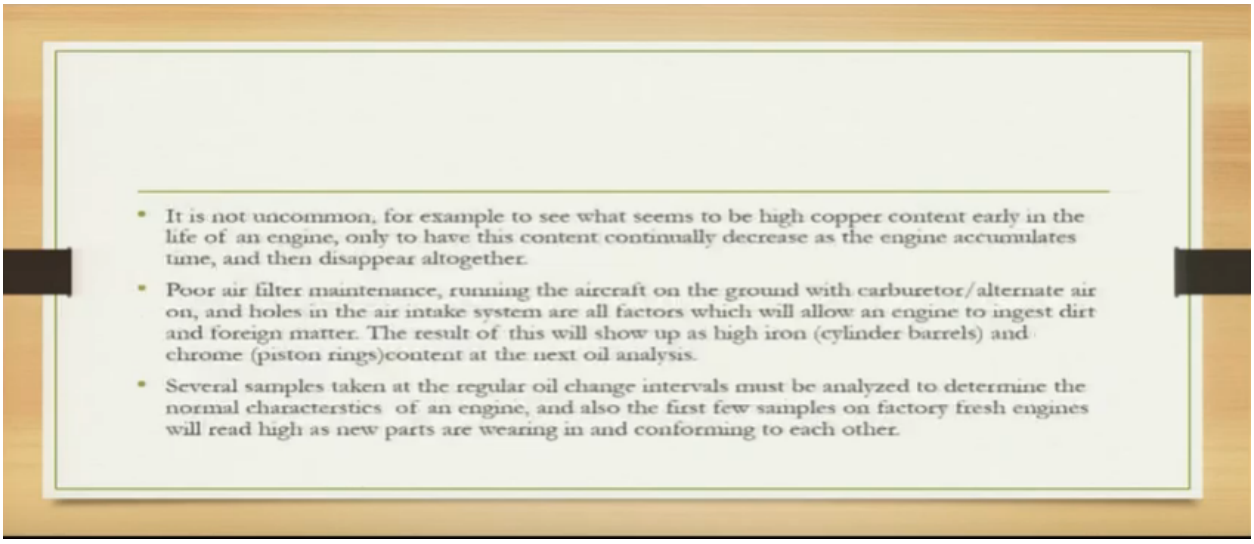

It is not uncommon for example, to see, what seems, to be highcopper content early, in the life of an engine, only to have this content, continually decrease, as the engine accumulates time and then, disappear together. So, in some cases, you will find that, some metal, is there, in large quantity, in the early stages and it gradually tapers off and gradually finishes, because in the initial condition when the condition is new, you, you can observe somewhere and gradually,it will finish, it will disappear. Poor air filter maintenance, running the aircraft on the ground with carburettor or alternator, air on and holes, in the air intake system, are all factors, whichallow an engine to ingest dirt and foreign matter. So, we have read about this earlier, in our earlier slide also, in case if your air filter, is faulty, is clocked or is damaged, we or your air intake system, there are holes in the heiress's intake system, you run the aircraft on ground, with carburettor or alternate air on, then you are ingesting dirt and foreign metalin the engine. The result of this will show up, as high, iron that is cylinder barrels and chrome: that is piston rings content at the next oil analysis. So, I don't know next oil analysis you will come to know: that because of this dudinjection, wear has taken place, inside the engine. Several samples taken at the regular oil change intervals must be analysed, to determine the normal characteristics of an engine and also,the first few samples, on factory fresh engines, will read high, as new parts are wearing in and conforming to each other. So, over the period of time several samples are taken, at regular oil engine intervals and the readings, should be analysed,to determine the normal characteristics and in case, if there is an abnormal where, if there is because, of some deterioration: that also, we need to see,in these reports. During the initial stage of the engine, when the engine is new, in the initial stage, we may see: that there are new parts, more bearing, is taking place inside and gradually, this bearing will diminish.

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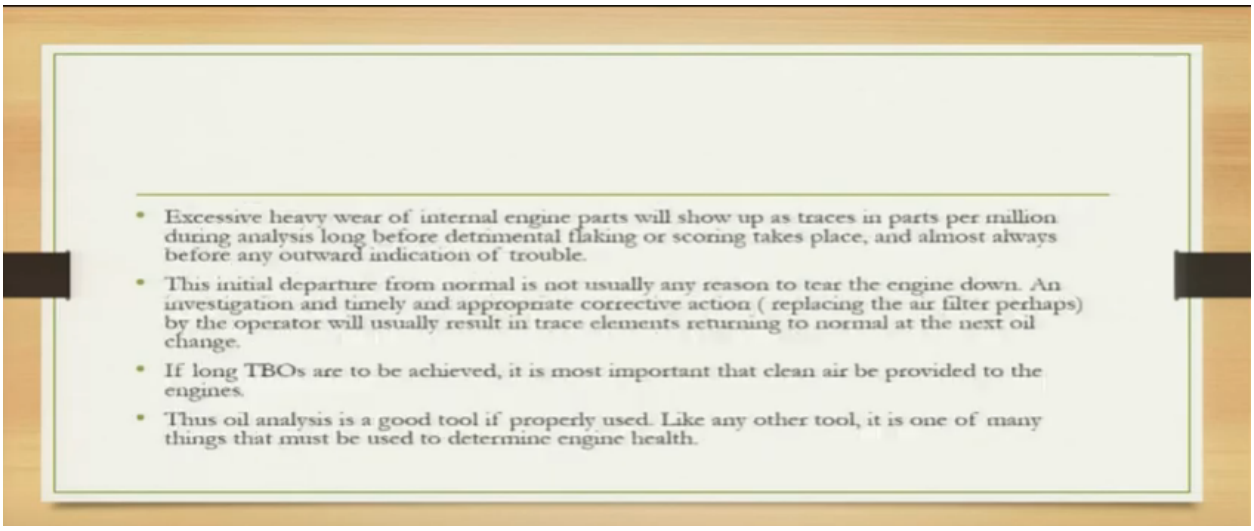

Excessive heavy wear of internal engine parts, will showup traces, as traces in parts-per-million during analysis, long before detrimental flaking or scouring takes place and almost always, before any outward indication of trouble. So, these excessive heavy wear of internal engine parts, thisis reflected, as traces, in parts-per-million, during analysis and at a later stage, itwill occur, as flaking or scouring. This initial departure from normal is not, not usually, any reason, to clear the enginedown and investigation and timely and appropriate corrective action, replacing the air filter perhaps, by the operator,will usually result in trace elements, returning to normal, at the next oilchange.So, during the reports, during the oil analysis reports if we see: that there is some wear, then we need to understand, the where, the cause of the wear and if the corrective action is taken then, in the next analysis report,we will see: that the problem has been solved. If long TBO, are to be achieved,it is most important that clean air be provided to the engines. So very, important point for an engine, for a reciprocating engine: that clean air should go, inside the engine and for that reason,the air filters are play a very important role.Thus oil analysis is a good tool, if properly used, like any other tool, it is one of the many things that must be used to determine engine health. So, we have seen, the different points, to ascertain, the engine health, apart from the previous points, oil analysis, this is also a very good tool,if it is used properly and this will help us, in determining the engine health. And these, things should be done regularly, to keep a close watch, on the ended engine condition.

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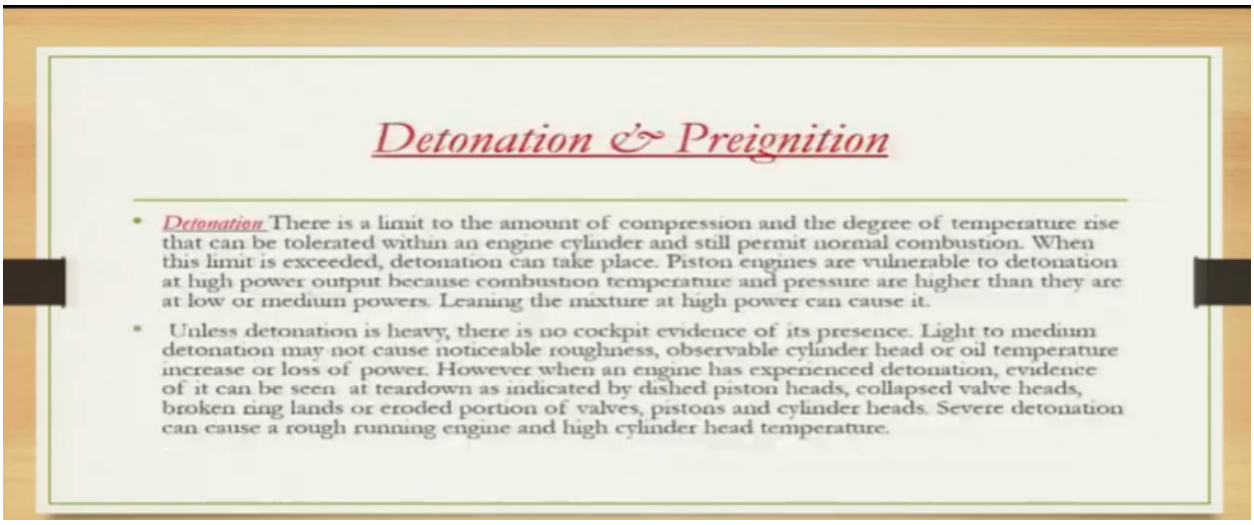

Now, next is the tradition and pre-ignition, these are, we have read about them, earlier also, just to brush up, what does detonation? What does pre-ignition? We need to be careful, about these conditions and this is just to brush up, these points. Detonation there is a limit to the amount of compression and the degree of temperature rise: that can be tolerated, within an engine cylinder and still permit normal combustion. So, the degree of temperature rise, the amount of compression, there is a limit:that can be tolerated within an engine cylinder. When this limit has exceeded, detonation can take place. So,when you have, temperature more than that,which is, what is prescribed? Or you have,more compression then, in that case,detonation can take place, piston engines,all over are vulnerable to detonation, at high power output, because combustion temperature and pressure are higher, than they are at low or medium powers. So, at high powers, you will have high compressions and high temperatures and so, piston engines are vulnerable, to detonation, at high power outputs. Leaning the mixture at high power can also, cause it. Now in case, if we are operating at high power and we lean the mixture, in that case also, detonation can take place. Unless detonation is heavy,there is no cockpit evidence, of its presence. Light to medium detonation may not cause noticeable roughness, observer,will cylinder head or oil temperature,increase or loss of power. So, the person who is operating, an engine,whose flying? The aircraft, he might not notice it even, in case if it is my detonation or it has light detonation, because that roughness or cylinder-head temperature or oil temperature increase: that probably he will not be able to notice or loss of power. However, when an engine has experienced detonation, evidence of it can be seen, at teardown, as indicated by dist piston heads. So although, during the course of operation, the operator might not be able, to understand whether,detonation has occurred or not, but,whenever the engine is, still open, for over all or for inspections, in that case we will come to know: that the engine has faced detonation, this will be indicated by ditched piston heads, collapsed, wall heads, broken ring lines or eroded portion of walls, Pistons and cylinder heads. Severe detonation can cause a rough, running engine and high cylinder head temperatures. So, in case if detonation is severe: that can be felt and the operator will come to know, when your engine will be start running rough and you will have high cylinder head temperatures. So,Severe detonation, will be noticed, will be noticeable, but, light and medium, detonation operator will probably,not come to know.

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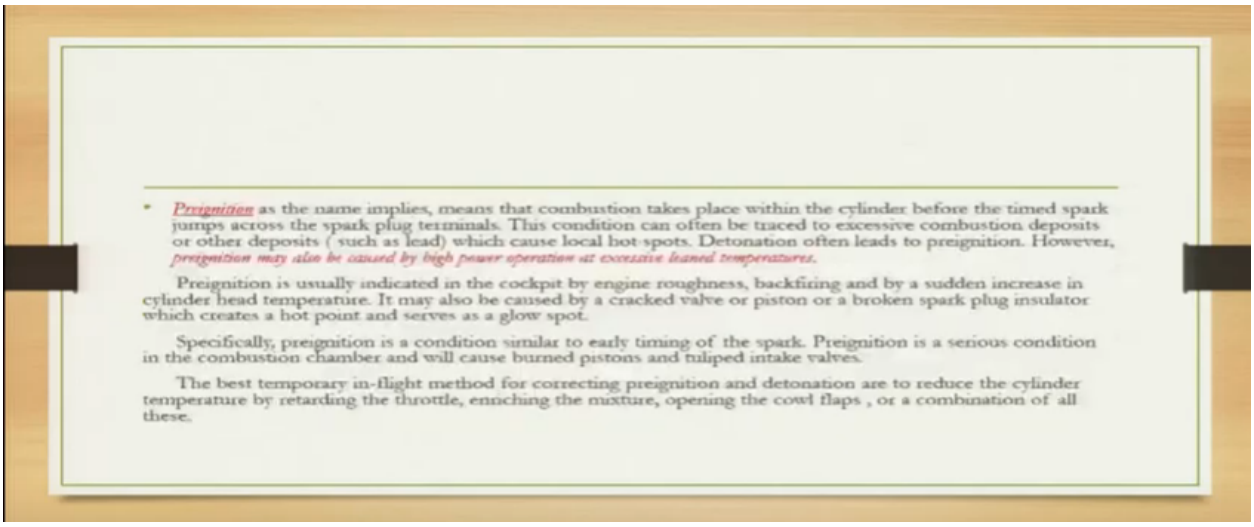

Next is pre-ignition, as the name implies, means that combustion, takes place within the cylinder, before the timed spark jumps,across the spark plug terminals. So, before the spark plug fires, before that if the combustion takes place, within the cylinder, that is preignition.This condition can often be traced, toexcessive combustion deposits or other deposits, such as lead, which could, call which caused local hotspots. So this is, because you have excessive combustion deposits or other deposits such as lead and these deposits become local hotspots and cause pre-ignition, detonation often leads to pre-ignition. So, first detonation happens and then pre-ignition happens, however pre-ignition may also, be caused by high-power operation, at excessively, lean temperatures. So, pre-ignition can also occur, because of high power operation, at excessive lean temperatures. Pre-ignition is usually, indicated in the cockpit by engine roughness, backfiring and by a sudden increase in cylinder head temperature. So, in the cockpit also, you can get an indication, when your engine starts running rough, when backfiring has happened or there is a sudden increase in cylinder head temperature. It may also,be caused by a cracked wall or a piston or a broken spark plug insulator, which creates a hot point and serves, as a glow spot. So, in case if the piston has cracked, wall has cracked or your spark plug insulator has broken, this will create a hot point and it will act as a glow spot. Specifically pre-ignition is a condition similar to early, timing of the spark, pre-ignition is a serious condition in the combustion chamber and will cause burned, pistons and tuliped intake walls.So, this pre ignition is basically, ignition happening before it is actually, planned and it is a serious condition, inside the combustion chamber and it can result, in burned pistons and tuliped it take walls. The best temporary in-flight method for correcting pre-ignition and decorate, detonation are, to reduce the cylinder temperature, by retarding the throttle and reaching the mixture, opening the cowl flaps or a combination of all these. So while, you are flying, in that case, if you notice that, your cylinder head temperatures have, have sharply increased or you experience engine roughness, in that case, during flying,the best thing is to reduce, the cylinder temperature, you can do that, by retarding the throttle, by enriching the mixture, by opening the cowl flaps or you can do, a combination of all these. So, this will take care of these problems, of detonation and pre-ignition.

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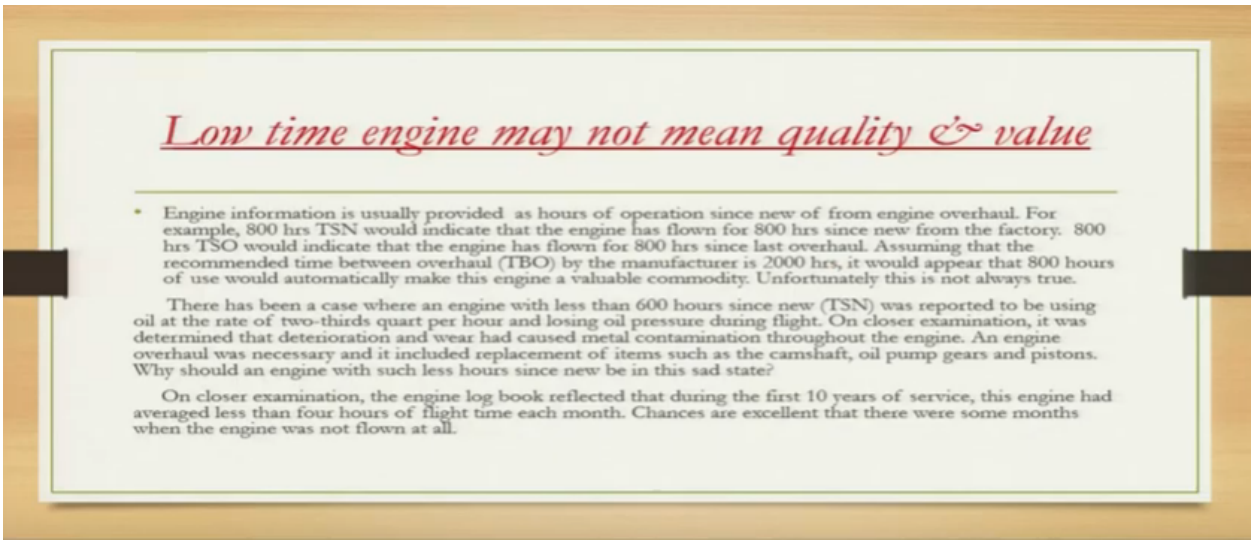

Now, next very important point, to be considered, is in case, if your engine is not being operated very regularly, in general as a,a conception is like if the engine has completed less number of hours, the condition is considered to be good. But,this may not be the case always, let us see, what happens? If your engine has is not operated regularly, what? How it can affect,the health of the engine, engine information is usually, provided as hours of operation, since new or from engine overhaul for example, 800 hours TSN, would indicate, then the engine has flown for 800 hours, since new or from the factoring. 800 hours TSO would indicate:that the engine has flown for 800 hours,since last overhaul. That means in case,if the your engine rock book, reflects 800 TSN or 800 TSO: that means, your engine has completed, 800 hours since new or 800 hours since overhaul. But, in case,if the manufacturer has recommended the life, as 2,000 hours or 12 years, in that case as compared to 2,000 hours,800 hours, will appear, as if your engine has not flown much and your engine condition is in a pretty good State. But, unfortunately this is not always true, there has been a case where, an engine with less than 600 hours since new was reported to be using oil, at the rate of 2/3 squat per hour and losing oil pressure during flight. Now, there havebeen cases where the engine, which had completed just 600 hours since new and it was consuming, oil at the rate of 2/3 quarts per hour and it was losing oil pressure during flight. Now, investigation was carried out, because the engine had just completed 600 hours since new and 1400 hours, were still left,to complete the life and still the engine was giving such severe problems,on closer examination it was determined that, deterioration and we're had caused,metal contamination throughout the engine. Now, when the investigation was done, it was found that there is little deterioration and we're and because of that, metal contamination throughout the engine has, taken place. An engineoverhaul was necessary, at and itincluded replacement of items, such asthe camshaft, oil pump gears and pistons.Now, the investigation revealed that, theengine now, needs an overhaul and during the overhaul, major components like camshaft, oil pump gears and pistons they need to be replaced. Now, the point was,why should an engine with such less hours, since new be in this sad state. Now, this is a very obvious,point to understand,why engine which, which was new and had just completed six hundred hours, why it has come in such a bad state, on closer examination, the engine logbook reflected:that during the first ten hours of service, this engine had averaged, less than fourhour, four hours of flight time,each month. Now, when the records were, investigated records were removed, it was found that, during the first ten hours of service, this engine has, on an average flown for four hours per month. Now, the chances were that, there was some months, when the engine was not flown at all.

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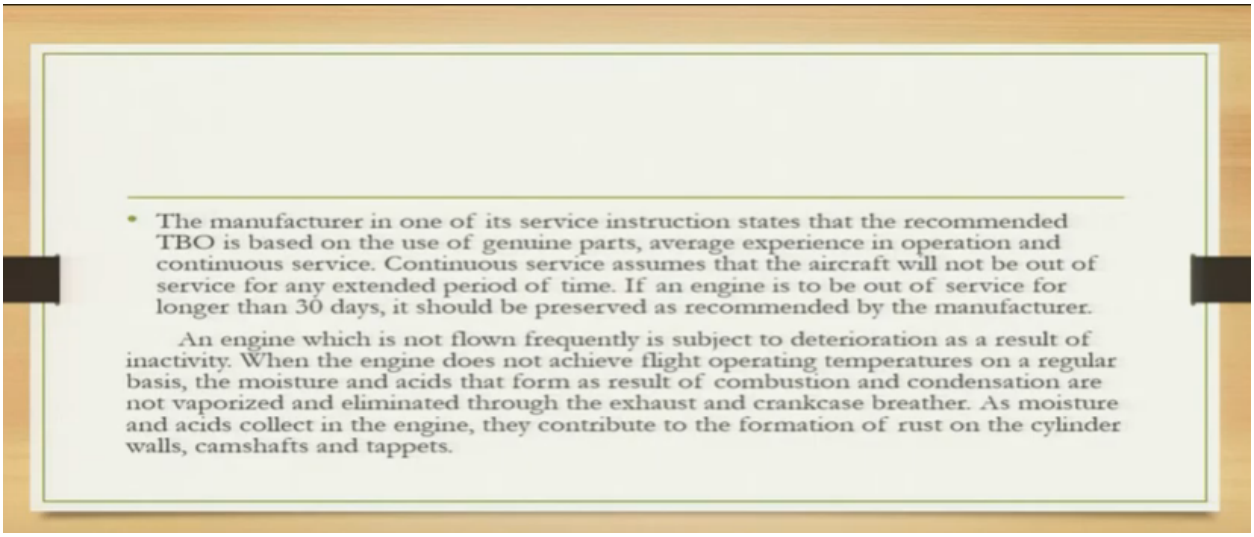

So, during the first ten hours of operation, the engine had flown on an average four hours, per month and there were cases, there were periods, when the engine had not flown, at all four months. The manufacturer in one of its and service instruction states: that the recommended TBO, is based on the use of genuine parts, average experience in operation and continuous service. So, the manufacturer in its maintenance publications and its manuals clearly, you see: that the engine is expected to complete; its complete life,only when, you use genuine parts, when you have average experience in operation and it is continuously, in service. Continuous service assumes: that the aircraft will not be out of service, for any extended period of time. Now, this continuous service means that, the aircraft will be in service continuously and it will not be out of service, for an extended period of time, if an engine, is to be out of service for longer than 30 days, it should be preserved, as recommended by the manufacturer. A very important point, very important point we need to understand:that in case, if the engine is not to be in service for more than 30 continuous days, in that case, the engine is required to be preserved, as recommended by the manufacturer, we need to follow, the steps,which are map which are mentioned by the manufacturer in their manuals, we need to put, the material whatever, lubricants, there is a proper procedure, for preservation, which is mentioned in the maintenance publications. And engine,which is not flown frequently, is subject to deterioration, as a result of inactivity. So, as a result of inactivity,the engine will deteriorate, when the engine does not achieve flight operating temperatures, on a regular basis, the moisture and acids that form, as a result of combustion and condensation, are not vaporized and eliminated through the exhaust and crankcase breather. So very,important point to understand, when the engine is not operating, on flight temperatures, on regular basis, then the moisture and acids: that form, because of combustion and condensation, they are not vaporized and eliminated through the exhaust and crankcase breather. As moisture and acids collect in the engine,they contribute to the formation of rust, on the cylinder walls, camshafts and tappets. So,because moisture and acids, they are collected in the engine, they will contribute to rust, in on the cylinder walls, camshafts and tappets.

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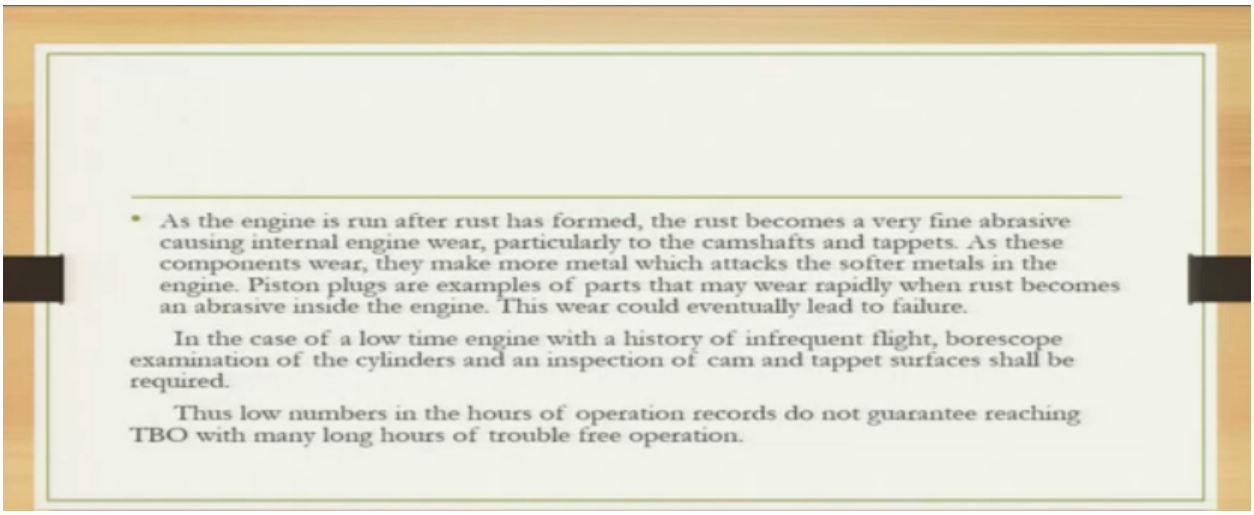

Now, when the engines are run, after rust has formed, the rust becomes a very fine abrasive, causing internal engine where, particularly to the crank, camshafts and tappets. Now, because of this rust, it becomes a very fine abrasive and it will cause internal engine wear, especially to the camshafts and tappets, as these components where they make more metal, which attacks, the softer metals in the engines. Now, as these components will wear, they will make more metal and will attack the softer metals in the engine. Piston plugs,are examples of parts: that may be rapidly, when rust becomes an abrasive, inside the engine.So, these piston plugs, they are made of soft materials, they are rapidly, when rust becomes an abrasive inside the engine,this wear, could eventually, lead to failure. So very important point, in the case, of a low time engine, with a history of infrequent flight borescope examination, of the cylinders and aninspection of cam and tempered surfaces shall be required. So, in cases where, the engine has not been operated frequently, where it has been left idle, for long periods, in that case, the borescope examination of the cylinders, the inspection of cam and tempered surfaces is very essential. The slow numbers and the hours of operation records, do not guarantee, reaching TBO,with many long hours of trouble-free operation. So now, we have seen that, in case, you find an engine with less number of hours: that will not give you a guarantee: that your engine,will give you trouble-free hours.So, there are certain rig inspections to be carried out, in case, if your engine has not been flown, continuously and in case, if the engine is supposed, to stay out of service for more than 30 days, it needs to be preserved.

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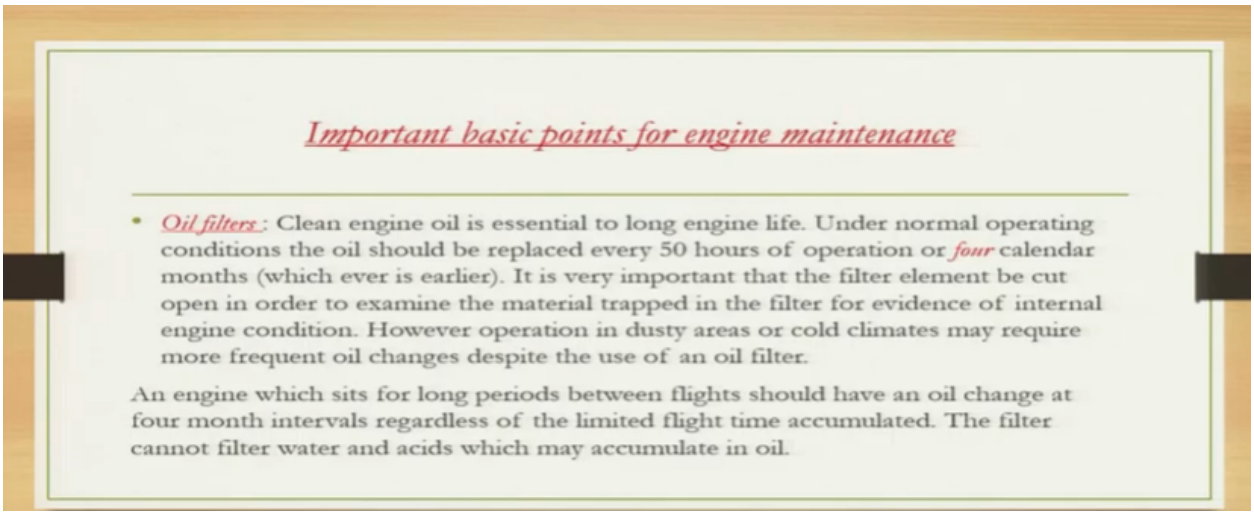

Now, some more important basic points, to be kept in mind for engine maintenance, some very, basic points, we have read them earlier also, this is just to brush it, oil filters, clean engine oil is essential to long engine life, we have just now seen yes, how clean engine oil is very essential, under normal operating conditions the oil should be replaced every 50 hours of operation, or for calendar months, whichever is earlier.This I had mentioned earlier also, the frequency of oil replacement, it is very important that the filter element be cut,open in order to examine, the material trapped, in the filter for evidence, of internal engine condition, however,operation in dusty, areas or cold climates, may require more frequent oil change, despite the use of an oil filter.So, in normal course of operation, the oil replacement is to be carried out at every 50 hours of operation or for calendar months, whichever is earlier, in case our operation is in dusty or sandy conditions, in that case, more frequent, replacement of engine oil and oil filter will be required, as mentioned by the manufacturer. And engine which sits for long, periods between flights, should have an oil change, at four-month interval,regardless of the limited flight time accumulated, the filter cannot filter water and assets, which may accumulate, in oil. So in case, if your engine is not operating very frequently, in that case also, the oil should be replaced, after four calendar months, it is very important, to replace it after four calendar months, because the filter will not be able, to filter out, water and assets, which accumulate, inside the engine in oil. We have seen, in a previous slide, how acids and water have accumulated, they get accumulated when your engine is not frequently used, in that case, your oil should be replaced every four months, very important.

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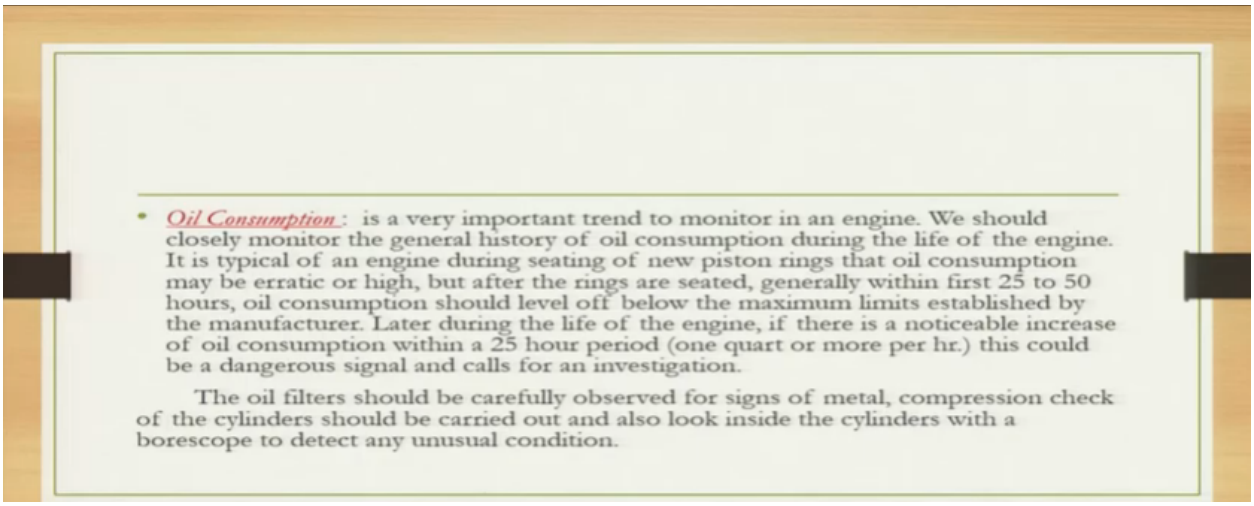

Next important thing is oil consumption, it is a very important trend to monitor in an engine,we should closely monitor the general history of oil consumption during the life of the engine, it is typical of an engine, during seating of, new piston rings: that oil consumption may be erratic or high. So in case, of a new engine you will experience high oil consumption, but, after the rings are seated, generally within the first 25 to 50 hours,oil consumption should level off below the maximum limits, established by the manufacturer. So, during the initial hours, during say first 25 hours or 50 hours,when your piston rings have not seated,you will experience more oil consumption and gradually, it will reduce, later during the life of the engine, if there is a noticeable,increase of oil consumption, within a 25 hour period, this could be a dangerous signal and calls for an,'Investigation'.So, once the oil consumption level has settled and during the course of operation if you observe, drastic,increase in oil consumption, then that is a cause of investigation and we need to investigate it properly. The oil filters,should be carefully observed for signs of metal, compression check of the cylinders, should be carried out and also,look inside the cylinders with a borescope,to detect any unusual condition. So, through your filter element,should be inspected, you should observe the compression, check of the cylinders and incase, if it is required then borescope, inspection should also, be carried out, to look inside the cylinders.

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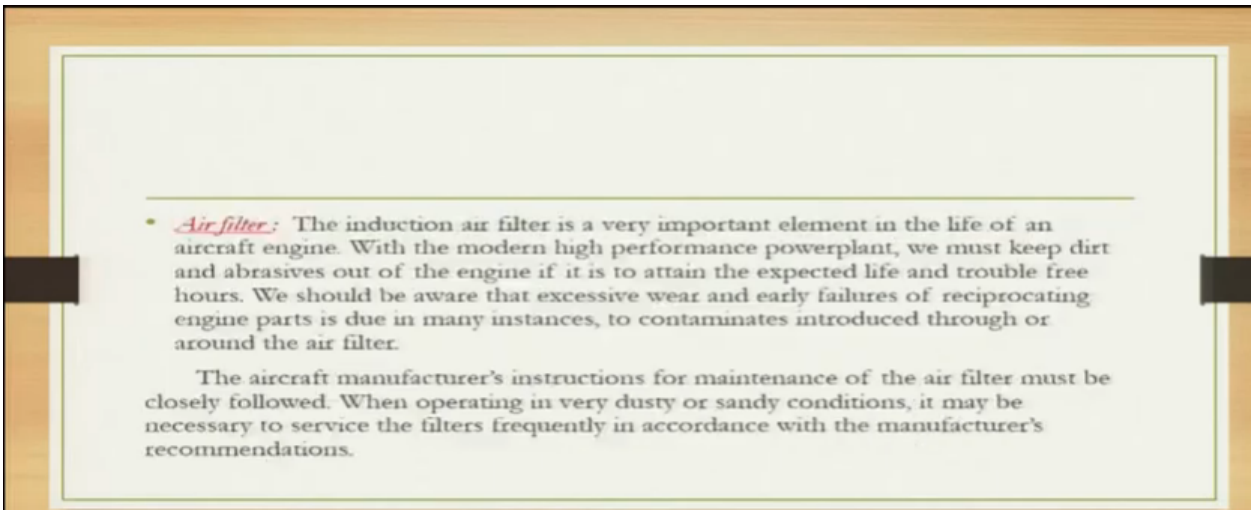

Air filter very important thing, we have read, about it earlier also, just to revise it, the induction air filter is a very important element, in the life of an aircraft engine, with the modern high-performance power plant, we must keep dirt and abrasives, out ofthe engine, if it is to attain theexpected life and trouble-free hours. So,we have seen in a previous slide, a clean air is very much, required for trouble-free life of the engine. We should be aware that excessive wear and early, failures of reciprocating engine parts, is due in many instances to contaminates, introduced through or around the air filter. So in case, if you are using a faulty, air filter our damaged air filter or a clogged air filter,then you will be ingesting dirt,inside and it will lead to, lot of fear and ultimate failure of the engine. The aircraft manufacturer's instructions for maintenance of the air filter must be closely followed, when operating in very dusty or sandy conditions, it may be necessary, to service the filters frequently, in accordance with the manufacturer's recommendations. So, the replacement frequency of the air filter,is mentioned by the manufacturers, in general, it is one year, every year you have to, replace the filter element, air filter element and at regular intervals, during the inspections, you need to clean them and in case, if you are operating in dusty or sandy conditions, in that case,we may be required to replace the filters, very frequently, in accordance with the manufacturer's recommendations.

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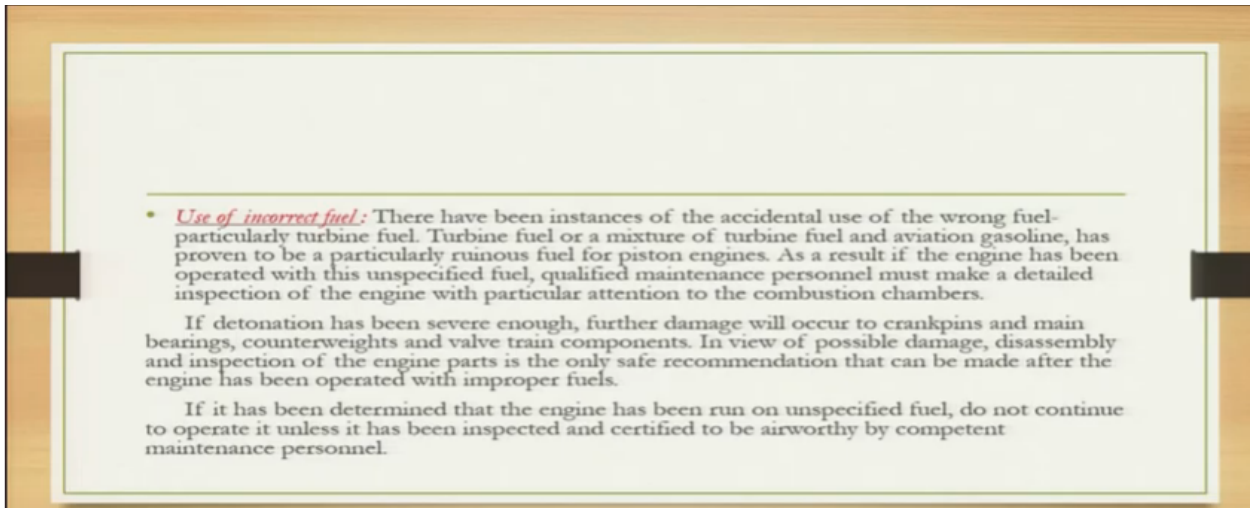

Next is the use of incorrect fuel. Now,fuel we have read, in our fuel system, chapter the types of fuel and it is very important, to use the right type of fuel,for the engine, there have been instances of the accidental use of the wrong fuel, particularly turbine fuel. Turbine fuel or a mixture of turbine fuel and aviation gasoline, has proven to be a particularly, ruinous fuel for piston engines. Now, in case, if you use a fuel other than that is recommended, by the manufacturer, say turbine fuel or a mixture of turbine and gasoline, then that, can doing your engine. As a result if the engine has been operated with this unspecified fuel, qualified, maintenance personnel, must take, must make a detailed,inspection of the engine, with particular attention to the combustion chambers.So in case, if the fuel has been, used with and with the fuel, other than that specified by the manufacturer in that case, the maintenance personnel

are required, to inspect the engines thoroughly, with a particular attention to the combustion chambers. If detonation has been severe enough, further damage will occur, to crankpins and main bearings, counter weights and valve train components. In view of possible damage,this assembly and inspection of the engine parts, is the only safe recommendation that can be made, after the engine has been operated with improper fuels. So in case, if the engine is used with improper fuel, then it is better to dismantle the engine and inspect the engine parts, if it has been determined that the engine has been run on unspecified fuel, do not continue to operate,it unless, it has been inspected and certified, to be air worthy, by competent maintenance personal.So, in that case, you have to get it inspected, get it dismantled, inspected and certified by qualified people and then only the engine will be air worthy,for flights. So, these were some of the basic points, what we had to see? During maintenance of engines, so that, we can have, trouble-free life of the engine. Now,apart from these basic points, there are few more points which we need to follow, whatever, publications, are available, whatever publications are provided by the manufacturer, we should have, all the publications with us, we should have, all the latest publications with us and we should, maintain the engines according to the recommendations, by the manufacturers,because freak, there are frequent revisions in these publications and we should keep our self-updated, about the latest developments and about the latest recommendations by the manufacturers. During the course of maintenance, in case,if we face any problem, if we encounter any snag or anything special or unusual,then that feedback should always be given to the manufacturer and we should take, the manufacturers advice also. This helps us also, while maintaining, our machine,at the same time, our experience,will also help other operators, because these,unusual things, this is recorded with the manufacturer and manufacturer can come up, with some solutions, so that, the others, will not face this kind of problems. So, very important thing, to keepthe manufacturer always, informed andalways we should consult, the manufacturers, we should follow, the latest publications, we should always follow the approved procedures and approve materials, while we maintain the engines or our aircrafts. So, this was all about the engine part and we have completed all the systems and the different procedures, different maintenance schedules and what are the and the basic points, to be considered while, maintaining the machine and an engine. Thank you.