Machinery Fault Diagnosis and Signal Processing
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Lecture - 50

Oil Analysis

Yeah in this lecture we will talk about oil analysis now yesterday or in the last lecture I had told you about wear debris analysis and as you know this wear debris get deposited in the oil which is lubricating oil essentially between 2 rubbing or moving components. So, in the process what happens the oil is also getting subjected to lot of temperature variations pressure variations and then you know sometimes it is get contaminated with the environment in the sense you know dust or dirt get deposited in the oil; apart from the wearing particles which we called as the debris which flick of the surfaces which are rubbing against each other. So, oil analysis is also, so when I talk about contaminant.

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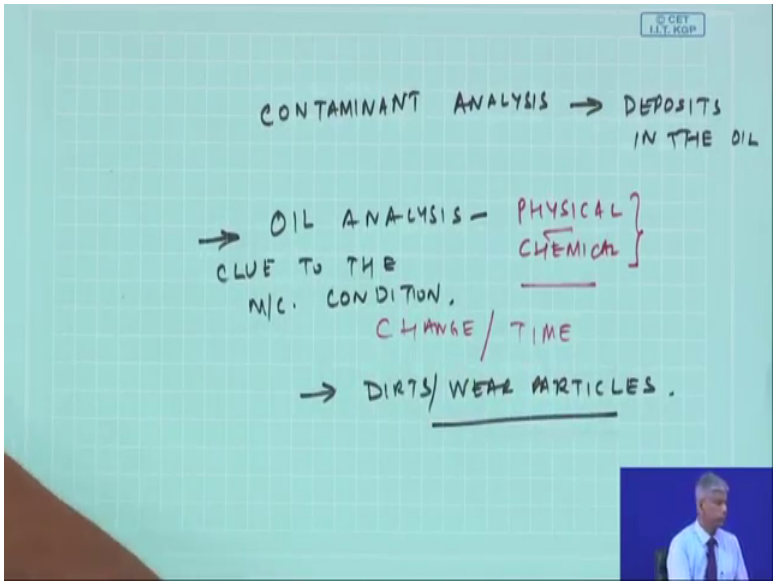

It is the deposits in the oil, apart from the oil itself because when the oil is developed or manufactured; it has certain physical properties and also chemical properties. So, these properties would vary would change with time because of the presence of dirt's wear particles etc. So, all gives us a clue to the machine condition right.

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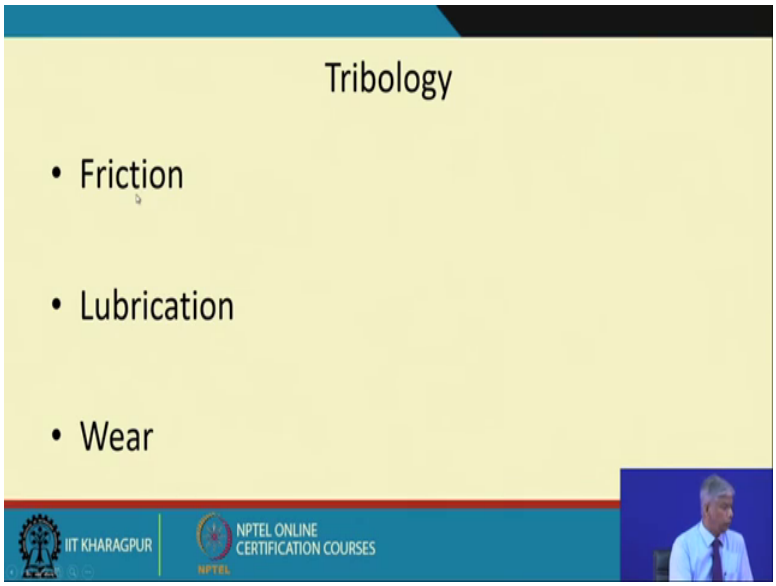

So, we know that the field of Tribology is nothing, but study of friction lubrication and wear. So, it is have this lubricant between the mating or moving components to reduce their wear and I mean to reduce the friction and in the process they wear out also. So, where we call as wear and tear are the machine, this inevitably happens with time because you know a small it very similar to I will give an example.

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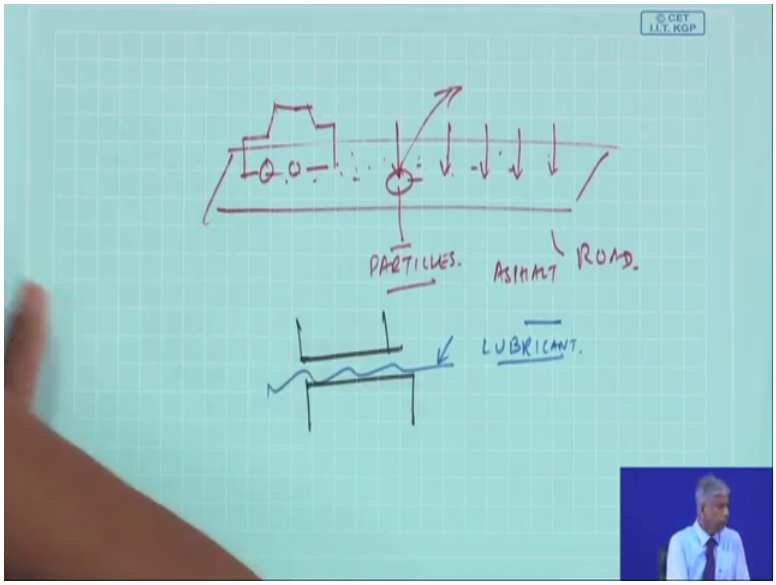

Suppose we have a road and there are certain asphalt roads, suppose heavy cycle vehicle goes over ok. So, because of the road what happens some of the particles will get

dislodged and this particles would what happen will get of course in the road, they get dislodged that imagine such a scenario happens between 2 mating components and then we have the lubricant ok. So, we will see how the properties change how to measure the properties of the lubricant, how to collect the lubricate and that is very important part of our study here.

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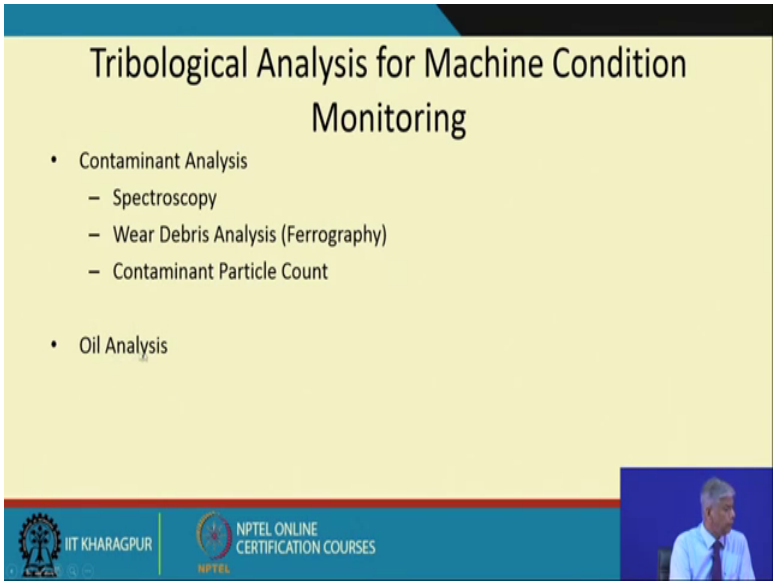

So, the containment analysis wherein we study in detail about the size, shape, nature and number of contaminants for given volume to and this was the clue as to what is wrong with the machine. But there is another part of this which is none of this oil analysis, so the oils property would change for example, oil to begin with had some specific gravity, oil had a viscosity, oil had an acid number or base number, so all this properties would change. It is very similar to maybe you know pathological analysis pathology test which we do on the human you know blood urine samples similarly we will do on the lubricating oil.

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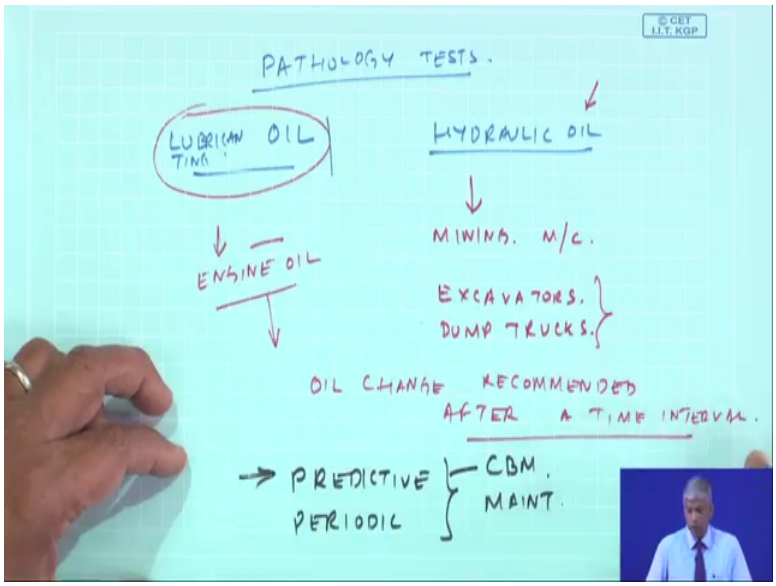

Well when I say lubricating oil I also we can also do them in hydraulic oil because, you will see many machineries particularly the mining machineries the booms excavators etc dump trucks. So, lot of hydraulic operation is done to lift the heavy loads and this oil quality can also be measured and of course in normal everyday life any lubricating oil be the engine oil and so on and all of you have must have experience now when we go to service your vehicle 4 wheeler 2 wheeler etc at a reputed or specified time we change the oil change recommended. After a time interval again if I recall a very first few lectures, wherein we discussed about whether I should do predictive maintenance or periodic maintenance to in predictive maintenance depending on the condition of the machine we do repair maintenance whatever.

But in periodic maintenance you know and regular interval we change may be the oil or fix the components inspect the components and so on. So, sometimes you know in a large fleet of machines or vehicles the engine oil, if it is changed at a fixed interval without even checking for the it is condition in the long run it may not be cost effective; but today the trend is we will do the oil change based on it is on it is condition.

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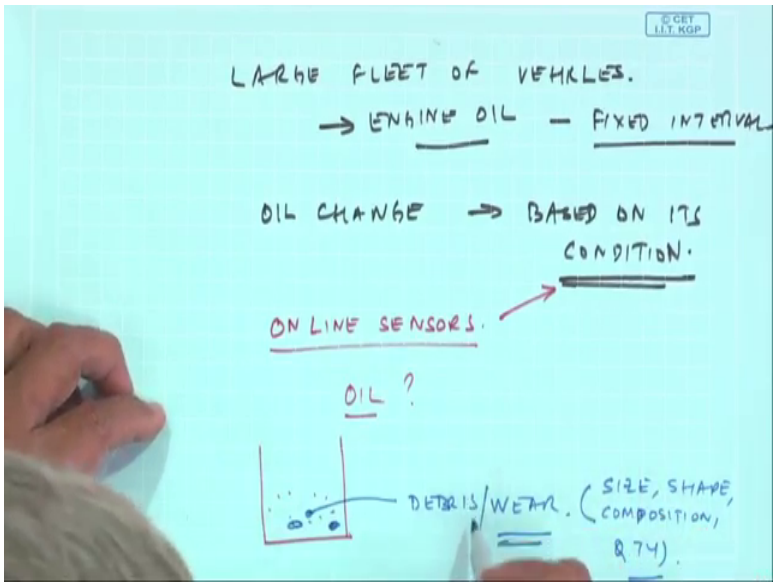

Now, who decides it is conditions it could be nowadays some online sensors are available to monitor the oil conditions and so on ah. That is little futuristic, but we will see when you talk about the oil analysis what exactly do we analyse. As you know this oil which I am collecting also will have debris or the wear particle ok.

So, yesterday or in the last class we talked about for the wear particles their size shape composition quantity gives a clue as to the nature of the wear and so on the origin of the wear etc. When I talk about origin of the wear even in the oil we have certain chemical elements ok.

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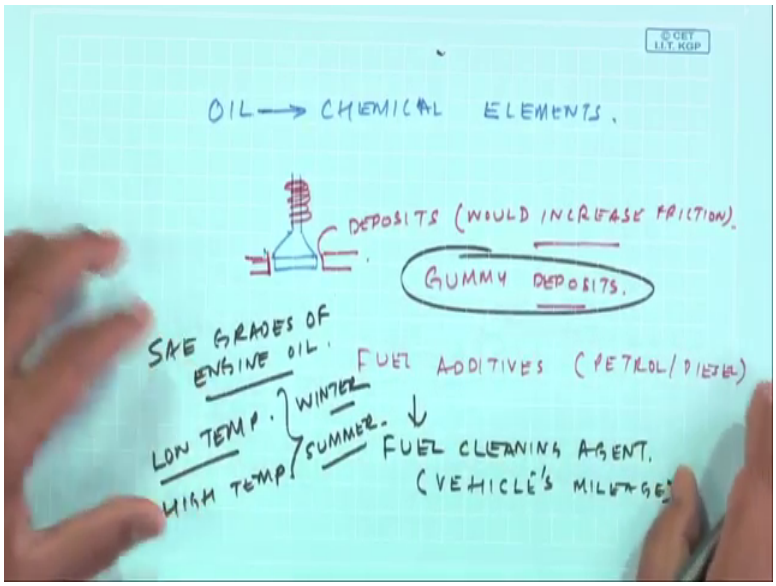

Oil also we have certain chemical elements which have been given artificially in the oil for the following functions.

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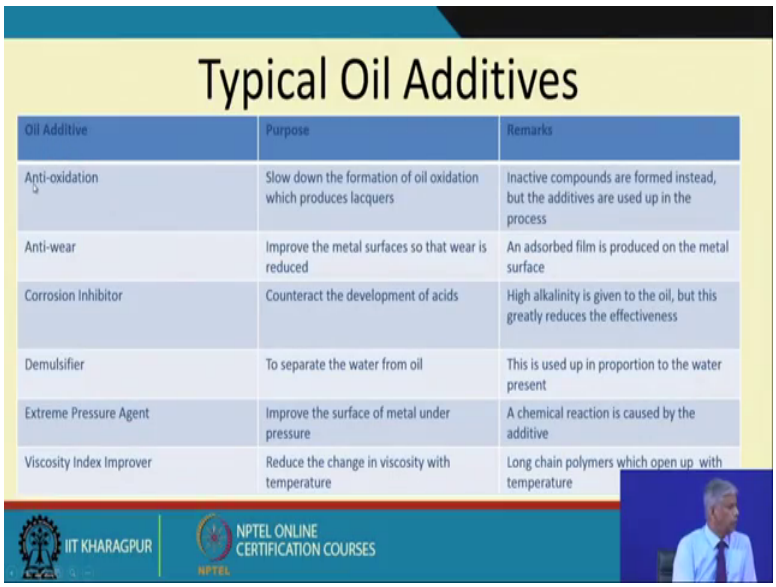

So, the oil additives are because of anti oxidation anti wear, corrosion, inhibitor demulsifier extreme pressure agent viscosity index improver. So, these are the reason why such additives are added and they are essentially chemical components. So, when I do an oil analysis or if I look the oil sample under the spectroscope I mean find someone elements. So, I should not be saying that this is a foreign element, so the oil is bad you

know. So, there are certain purpose why this anti oxidation is there slow down the formation of oil oxidation which produces lacquers could form a dummy deposit on the mating components increase the friction, you know in the valve sittings etc. They may damage the valves you know in IC engines we have this valves sitting on some and the spring loading valves.

So, imagine if this deposits come here they would increase a friction would increase friction ok. So, to remove this dummy deposits we can do that of course, you know commercially we will see in any of the fuel we add additives in your vehicles beat petrol or diesel, sometimes you know the manufacturer recommends to put fuel cleaning agent which would improve your vehicles mileage because, what happens this should clean the systems this should remove this dummy deposits friction would reduce and so more life and more power output of the.

Similarly, improve the metal surface that wear is anti-wear elements are given corrosion because, you know if acids are form they will enable corrosion demulsifier to separate the water from oil improve the surface of metal under pressure viscosity index as you know is greater with the viscosity changes with temperature. So, this change could be reduced by using the viscosity index improver you recall that when you talk about engine oil there are certain sae grades of engine oil; which are based on their viscosity index.

So, at low temperatures we use a different grade of oil at high temperatures by low and high, I mean the low ambient temperature of the high ambient temperatures like an particular oil for winter and particular oil for summer in our country because, the temperature differences are not extremely high. But you go to the you know close to the northern hemisphere to the polls were the temperatures are high for example, in Canada etcetera we have 2 different grades of engine oil being used 1 for the winter and 1 for the summer. So, all these are good for the oil and they have all been added in the oil for a purpose ok; but these elements will show up in the oil and then we have to be careful about.

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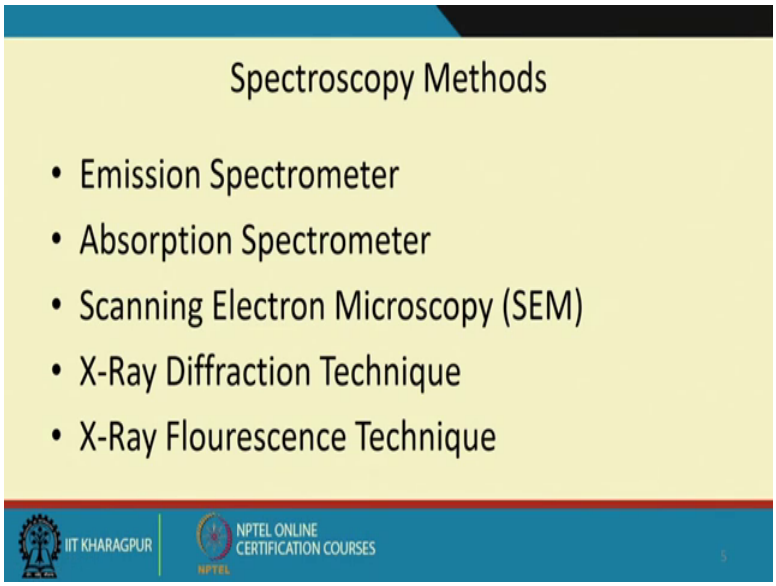

Now, we had discussed about few of the spectroscopy method, this spectroscopy methods could be used to analyse the oil.

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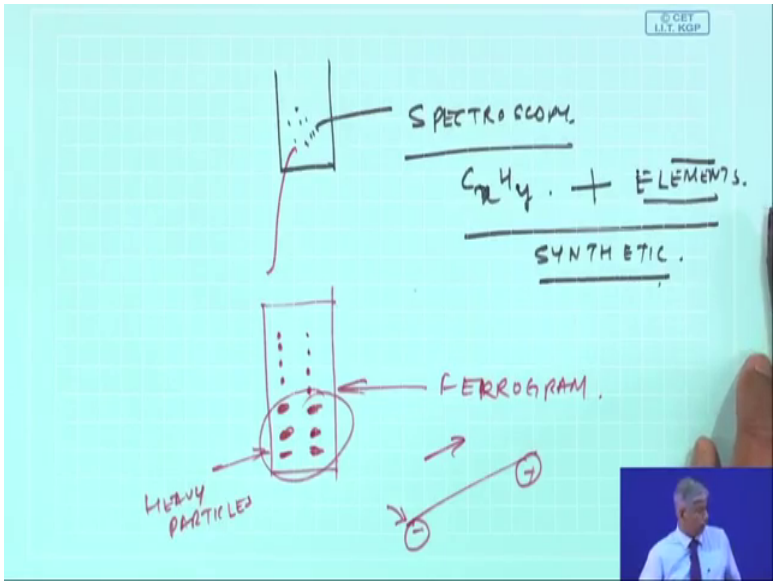

I take the oil sample and do a spectroscopy because, no matter what there are oil essentially you know some hydrocarbon compound Cx Hy maybe or some combination so and then plus certain elements because we are developing synthetic oil also ok, so all these techniques could be used and of course, when this oil comes with the wear, I can make ferrograms out of this oil. Where if I take this oil and put it on an incline feed like

this, a paper role which is being driven and this is smeared with oil which has contaminants and I will get a ferrogram because, of the gravity the heavy particles are come to the bottom of this paper and then I can bake it. So, this also gives an indication as to what is the amount of deposits being put in the oil and with time we can do that also.

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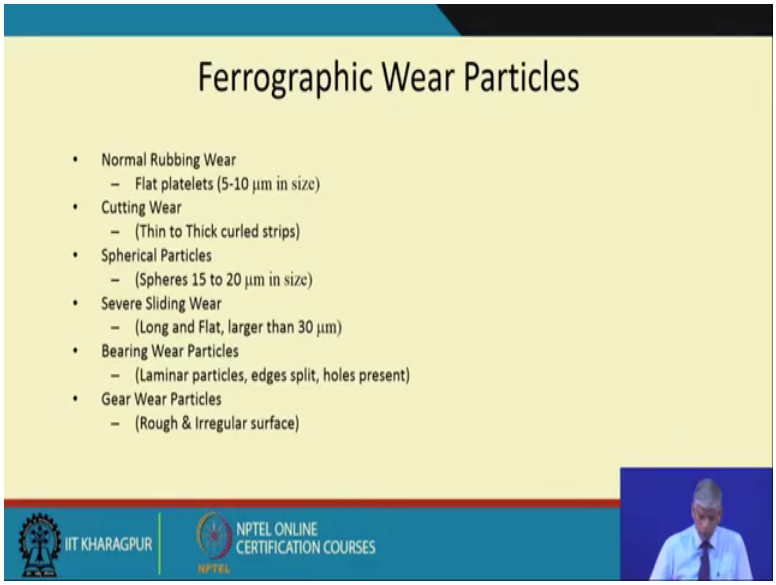

So, this ferrography oil wear particles which are large sometime it can be seen by naked eyes and also by microscope. So, normal rubbing wear they are flat platelets or 5 to 10 micron in size cutting wear, thin to thick curled strips spherical particles sphere 15 to 20 microns in size severe sliding wear long and flat larger than thirty microns, bearing wear particles laminar particles edges split holes present gear wear particles rough and irregular surface.

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So, as you all know the when we do an wear debris composition which are indicated in the which are present in the oil, the quality and composition of wear metals allows us to set alarm levels. So, if I look with time by the way I was telling you this is not real time unlike vibration mounting where things are in seconds, this could be months may be or quarter may be, first quarter second quarter.

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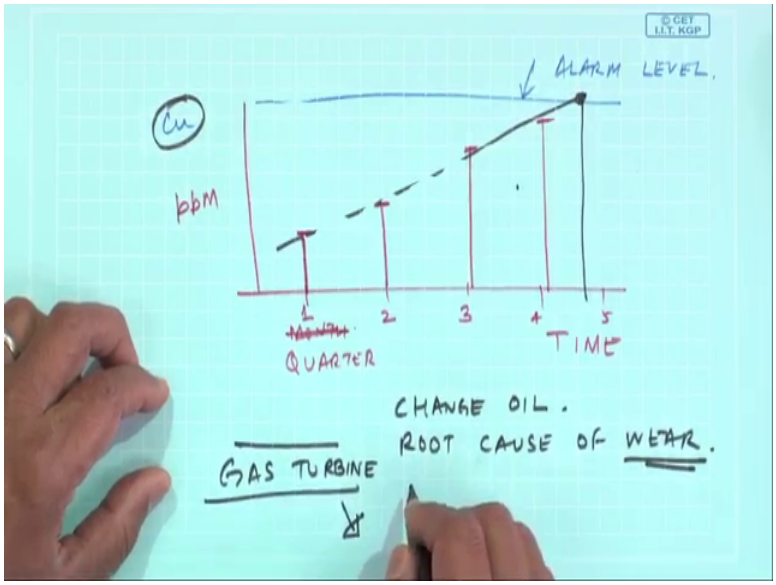

I can set for a particular elements say for example, copper in a bearing this could be my alarm level; through spectroscopy I will see the parts per million may be in the first

quarter it is here second quarter it is here, so in a third quarter. So, this kind of trending can be done and then I will know may be if I extra pull it linearly perhaps and this has rich.

So, I can say time to change the oil before this or to or to be worried either to change the oil; of course, we need to change the oil because oil has got contaminated and also find out the root cause of wear because, wear has to be arrested. So, quality and composition of wear metals wear metals copper as a wear metal allows to set alarm levels and most importantly knowledge of metallurgical composition is helpful in localising source of wear metal production.

For example I have large maybe a gas turbine, in fact many of the gas turbines you know which we import for a you know aircrafts sometimes the material composition is not known ok, because the that is you know trade secret of the manufacturer of the gas turbine as to what is the material composition.

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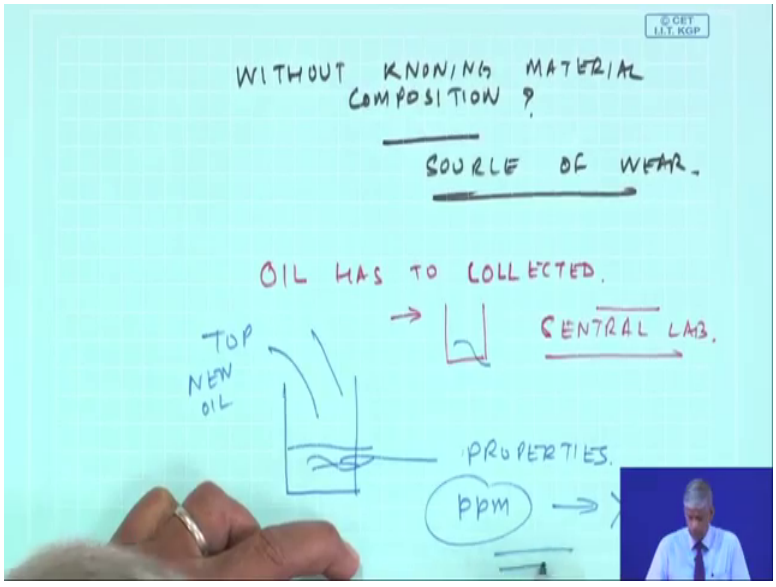

So, sometimes without knowing material composition, it becomes difficult to find out the source of wear there is something very careful about.

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So, as you know in the strategies of wear contaminant analysis catch faults early identify precise source of fault and identifying the abnormal wearing conditions ok.

So, wear particle analysis tactics improve the quality trending and density of the data, false positives environmental contaminants during sampling because, this oil has to be collected oil has to be collected and this has to be sent to a lab and then we have to get as to what is wrong with this. But sometime in the process suppose I have a machine when there is a oil, so oil with time the properties are going to change, but in between somebody has stopped new oil. So, all your calculations of the concentrations of parts per million or change ok, so 1 has to keep this into mind.

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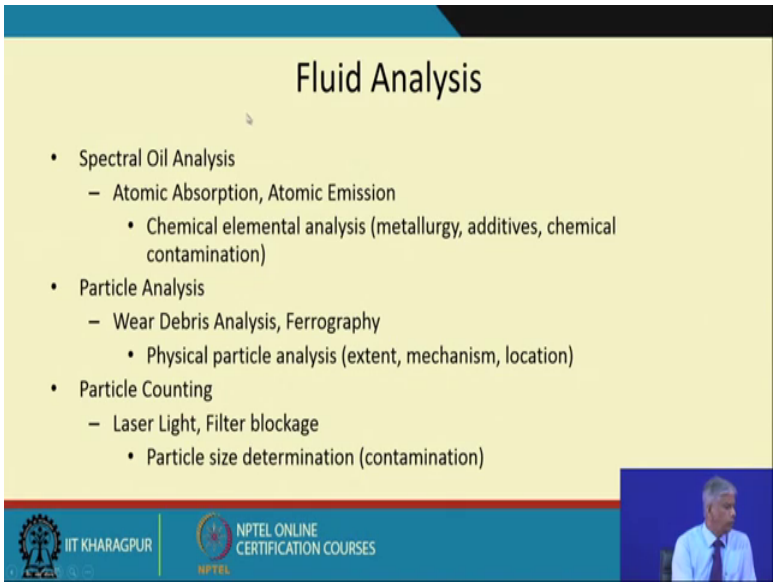

So, the fluid or oil which we talk about we calculate do the chemical element analysis by atomic absorption spectrophotometry or atomic emission spectrophotometry, particle analysis by wear debris analysis ferrography looking on the microscope and if the particle size is high we can use a particle counting by laser light or a filter.

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So, some of the metals present in the oil if it is metal only I can say confidently it is because, of a metal wear if the oxide I can say because, of corrosion and if there are dissolved metal components I consider there is a chemical corrosion.

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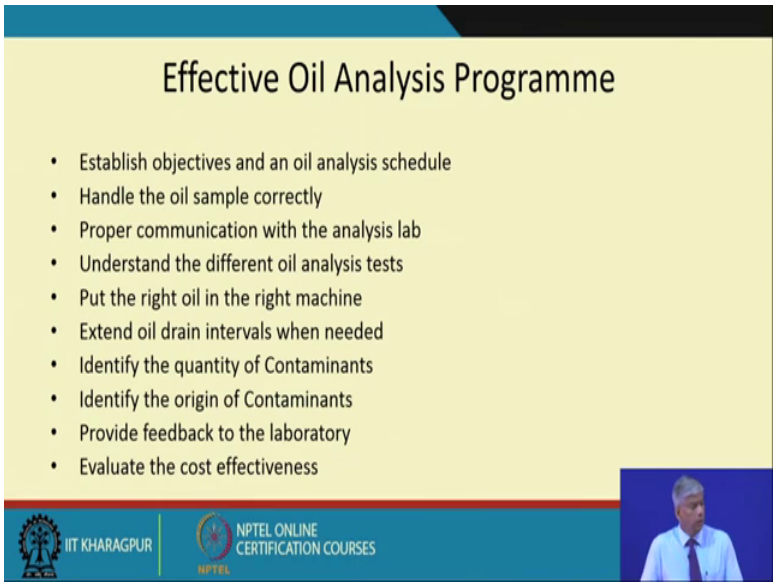

So, the effective oil analysis program needs to have this in mind because, see I have I am plant owner I have a machine this is plant and this is central lab where oil analysis is been done.

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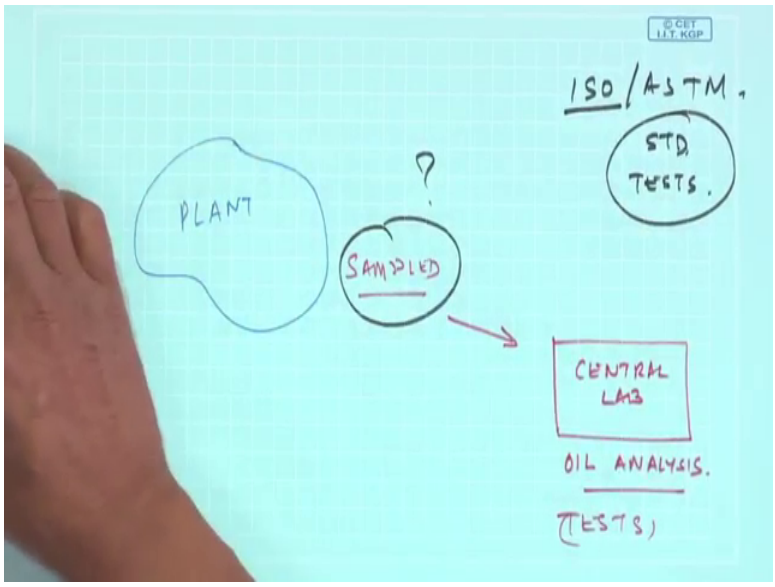

So, the oil has to be sampled and sent to this lab for doing all the tests on the all. So, we should have a regular frequency handle the oil sample correctly, proper communication in the lab that is very important I mean to know which machine we have collected this oil and send with lab and then you have to put the right oil because, there are different

machines having made in different types of oil, identify the quantity of contaminants origin of contaminants feedback to the lab and evaluate the cost effectiveness.

So, this is not done real time it has to be sampled and so on. So, this sampling forms a good basis of all analysis. So, some of the tests for oil analysis which we do is to determine it is viscosity find out the contaminations fuel dilation solids content fuel soot oxidation and nitration.

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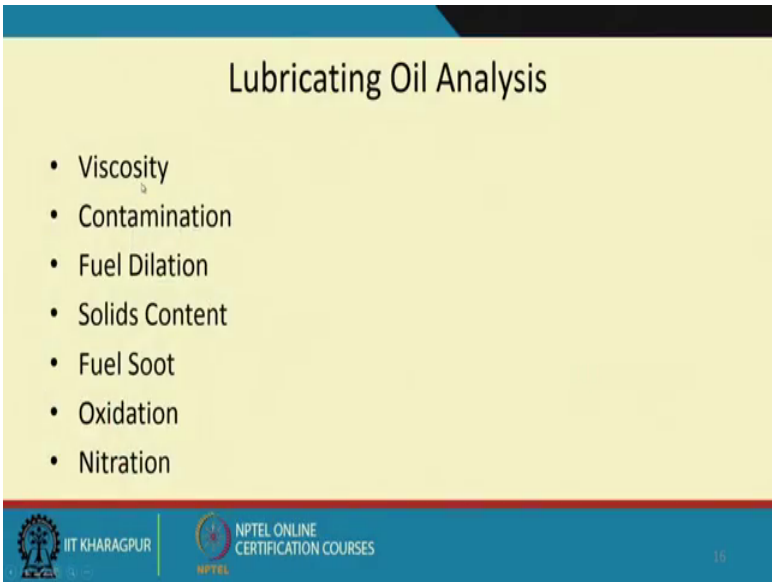

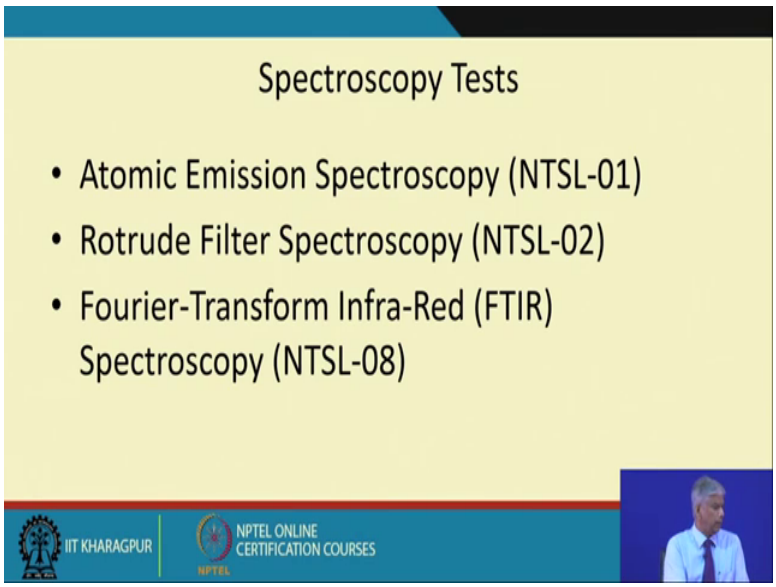

Some of the spectroscopy test I have just listed down, the standard references you know you can refer to the standards which are internationally standard the reason we do all the

tests, to a standard is because many a times these results have to be compare with another plant or another lab. So, all the test has to be standardised standard tests are used and there are ISO or ASTM standards for doing this oil analysis.

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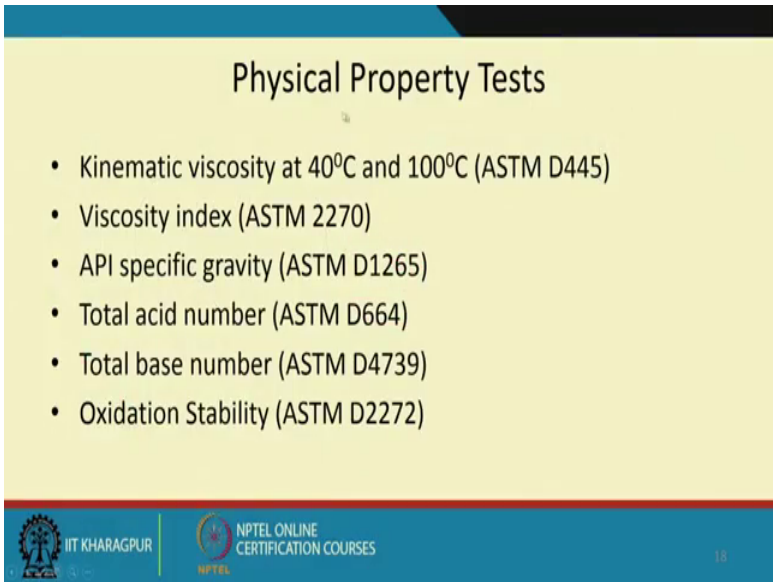
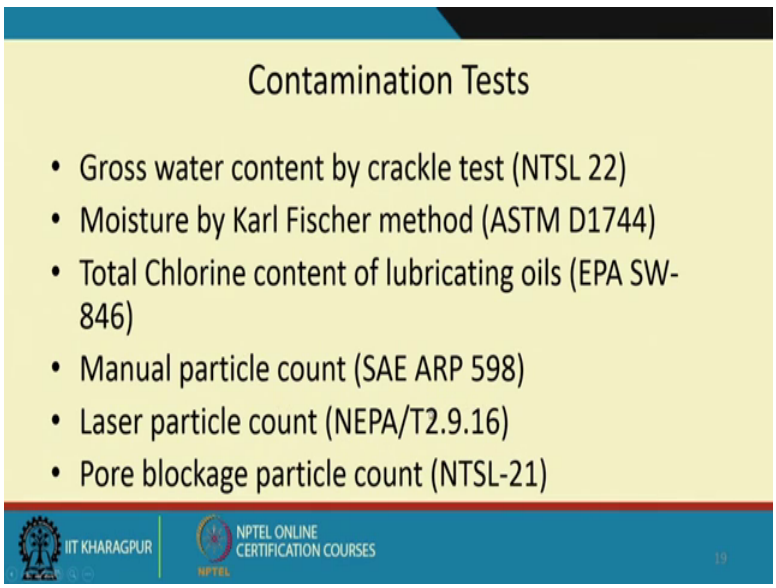


Similarly, some of the physical property tests which are done on the oil, are mostly based on some of this ASTM standard which I have mentioned here the kinematic viscosity at 40 degree Celsius and 100 degree Celsius, viscosity index specific gravity acid number base number oxidation stability etc. So, the reason I am mentioning the standards is when we send a oil to a lab we can specify that please do the test as per these standards and similarly for the contamination tests.



And similarly for the wear debris test.

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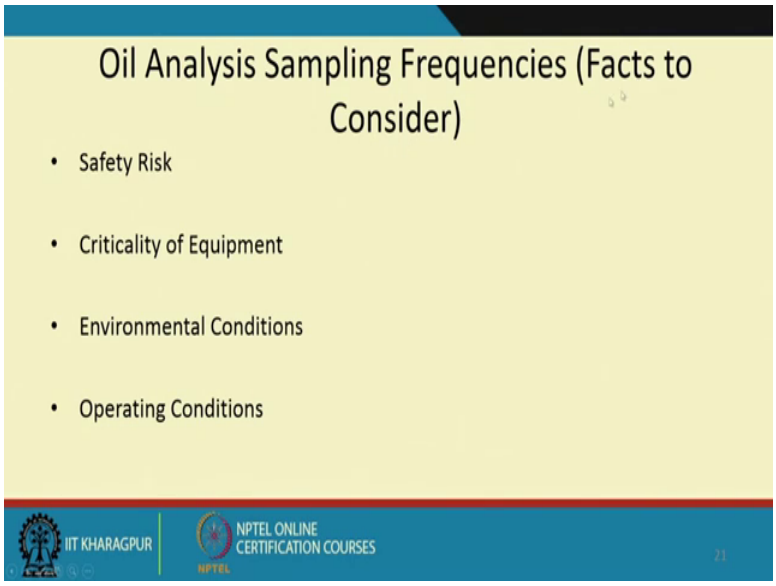

So, oil analysis sampling frequencies facts frequency that with the safety risk criticality of equipment, environmental conditions, operating conditions; imagine the oil which you take from land based engine with a different the frequency would be different than from an air based engine or from an water based engine you know. May be an aircraft engine you need to monitor the oil quality more frequently than perhaps railway rail road locomotive that depends on the criticality.

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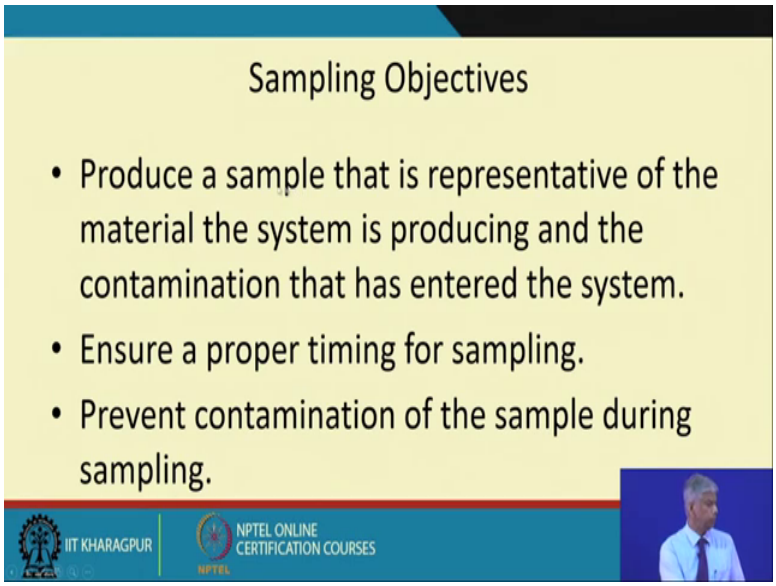

So, when you sample a oil please collect a sample that is representative of the material the system is producing and the contamination that has entered the system, ensure a proper timing for sampling prevent contamination of the sampling sample during sampling.

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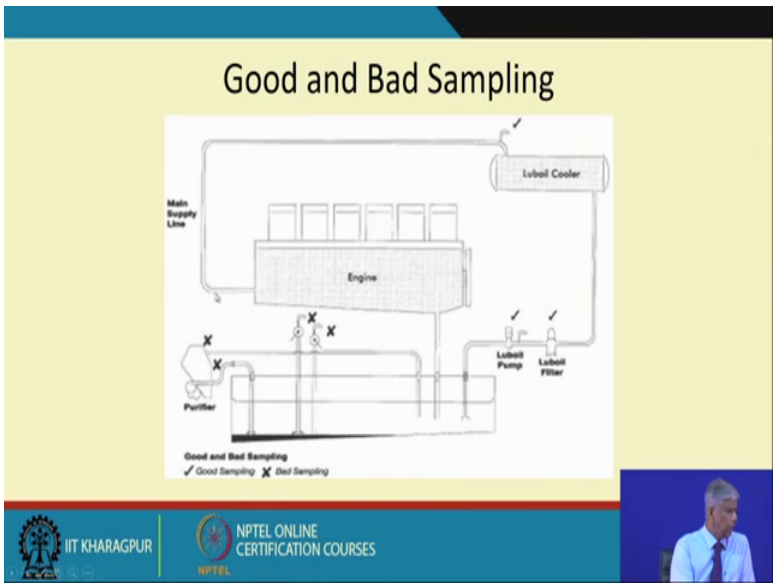

So, this is an engine and there is an oil supply lines never collect from these points which are dead points, rather highway bypass loop and collect the oil when the oil engine is an operational engine oil is inflow because, if the engine was not running all the deposits

would get loop to the engine crankcase and get deposit in the bottom of the tank here. So, some of these are some of the good points not to collect the oil.

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And of course, the oil has to collected with clean sampling bottles there are ISO standards to collect this oils and always use a vacuum Pump.

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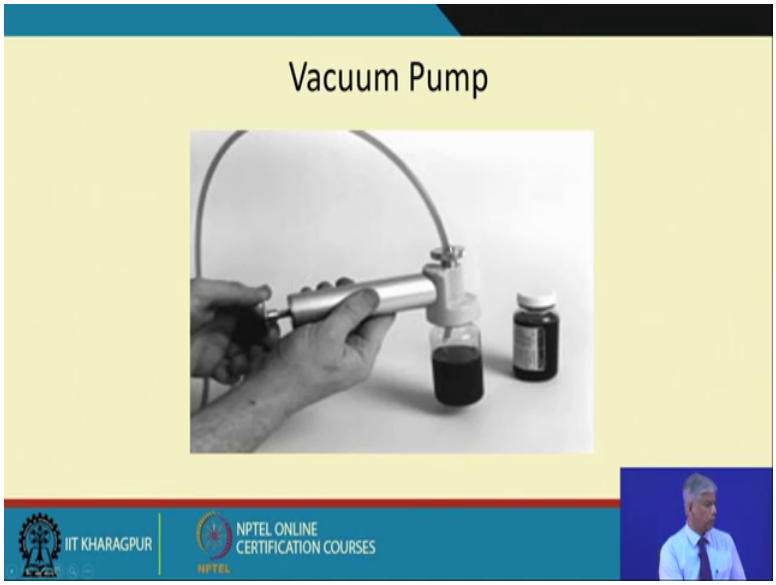
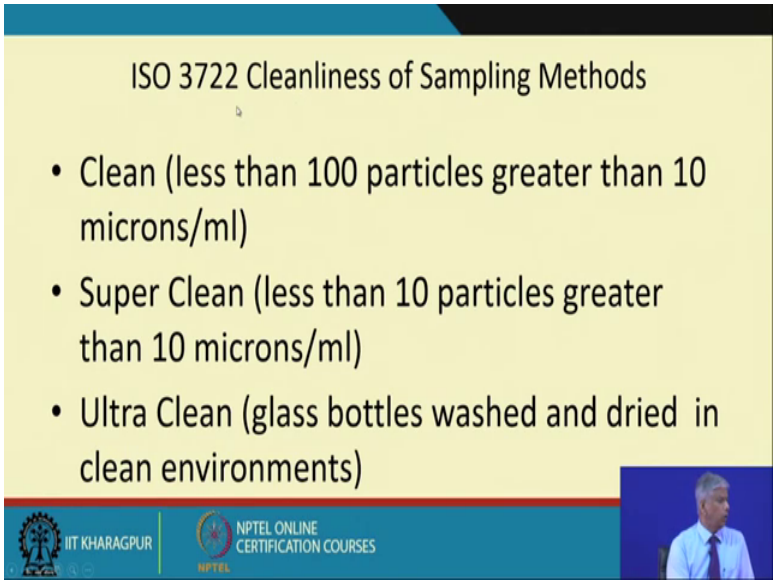


So, that the this is put to the oil and this tube need to be replace other there will be cross contamination and you have this bottle is seal it label it and now this oil cleanness sampling methods as per the ISO standards.



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There are ISO 3722 it tells you how clean if when you say the oil all sample bottle is clean super clean and ultra clean what should be the condition ok. So, some of these standards you can see in my book and then we can do oil analysis to prevent failures.

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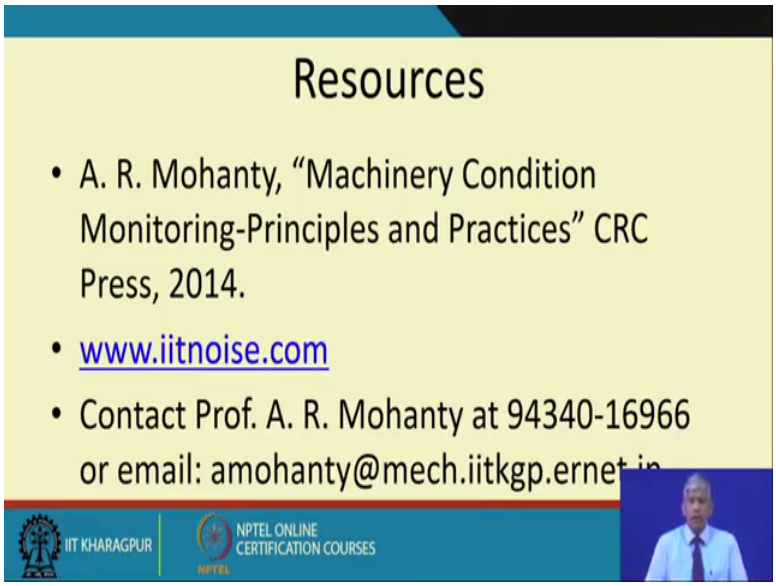

Thank you.