Bulk Material Transport and Handling System
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Lecture - 31
Monitoring and Maintenance of Processing Plant Equipment

Welcome students, we have discussed so far introduced number of things number of machines number of systems then we also introduced that what is mineral processing and mineral processing plants. So, today we will be discussing a little bit different that is we will be talking about the maintenance and monitoring.

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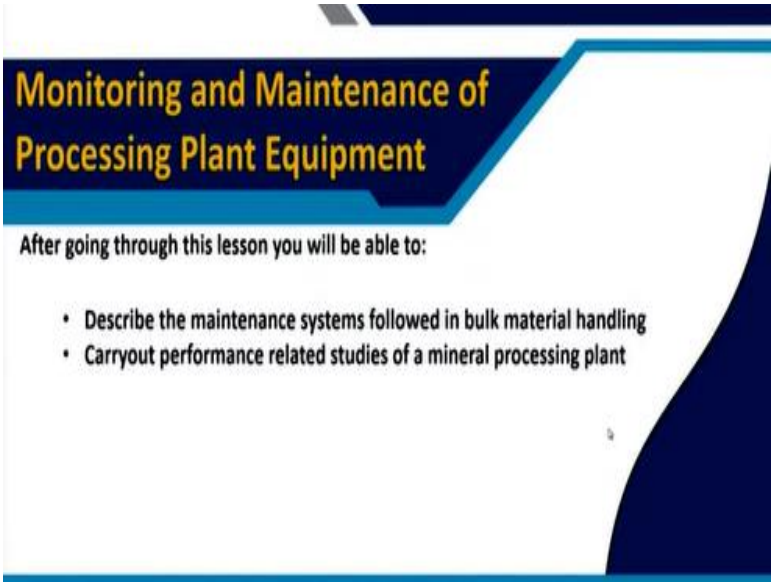

So, after this class you should be able to describe the maintenance systems followed in a bulk material handling particularly in the mineral processing plants. We will be giving a just a bit introduction of this mineral processing operations and we do not go to the main processing, hand processing operations. But the handling before doing those mineral processing then carry out performance related studies of a mineral processing plant.

Because the whole operation of a mineral beneficiation plant or a coal washery their job is to handle a huge quantity of bulk solid material and then prepare it for the different processing jobs. In doing so we introduce lot of machines you have heard of this, your receiving hopper, crusher,

screen then conveyors we have got this whole system may be having in your receiving section, you will be having sticker reclaimer.

So, all these machines for their perfect operation they need to be maintained well because at the time of designing the things are taken care of. But during operations if you are not taking care of that what type of situation it can handle and then if a problem comes or it starts coming at that time if you do not take timely action, systems can go wrong.

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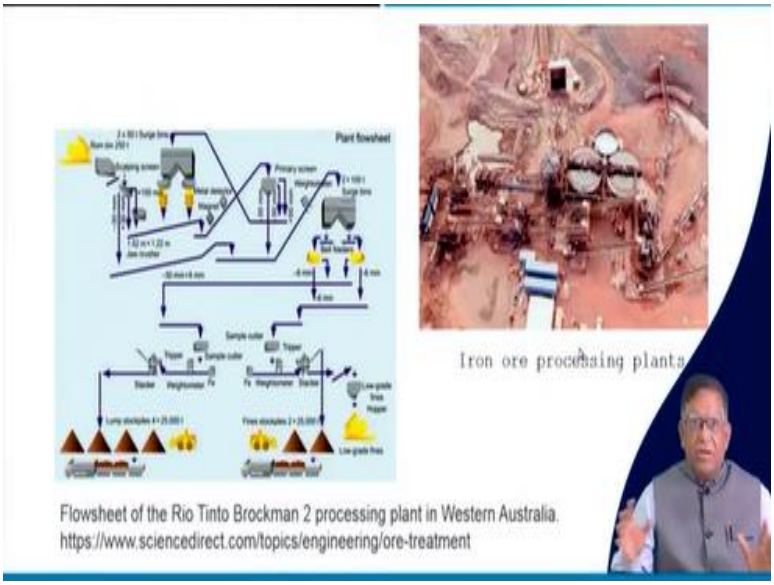

So, that is why this is a very practical oriented things that you need to know. So, here two figures are here I have just copied from net that is one is showing this side it is a picture of a iron ore processing plant where they say openly they are keeping all this that iron ore from the mines, how they are coming, they are crushed then they are washed then they are beneficiated to certain extent.

The other one is showing in a your the schematic diagram for how that write into that big company they are having in western Australia they are planned. It also shows that how that run of mine material iron ore when it comes, they give to a that receiving hopper from there going to a scalping screen and then they differentiate that their minus 30 and plus 30 sizes. And then they go with a series of conveyor belts and they are taking up and then again there are closed loop as well over open loop systems.

Ultimately, they bring that through the feeders they are bringing it to your another by conveyor systems to a tripper to a stacker. So, that it is going and stacked over there and from there it is dispatched by wagon loader and things like that. So, same thing is coming for the other product also they are bringing it. So, they have got a stockyard and then they have got.

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So, basically what is there in any mineral processing plant they do lot of activities that from the surface layout as you have seen in the figure you know that where is what. And then you have got this the main job of the processing plant that is say it will be bringing this thing that concentration will be improved. You have learned those operations of handling operation like comminutions, sizing then gravity concentration, magnetic separation those you study in your mineral engineering classes.

But this whole system involves number of machines like size reduction machines you have got different primary crusher, secondary crushers, tertiary crushers. They have got so many different makes they make it then these machines have got various components. Components in the sense there are the machine elements combined together for a common purpose to do that that is a machine.

But for that machine may be having some of this your operating part that is where the energy is given from one and to the another one to give some motions. That is wherever you are having the working member the working member will be having a motion which is exactly being brought from a source of energy. So, there is a different type of drive and then there would be either a linear motion or there would be a rotary motion.

Wherever rotary motion things are there with a bearing it is having in linear motion so, there will be having exactly sliding motion. So, these surfaces of different parts they are subjected to wear and tear then there would be that is your in the drive sections in your transmission sections are everywhere they may be subjected to some abuse because of the may be overload coming, may be overheating coming.

So, under this condition you need to maintain it, maintain means every plant has got a life. So, that means your plant will have to do say for 12 or 15 years. So, your equipment what you have brought it should go up to there. You do not want to replace the whole unit but by that some of the elements which are getting used more loaded more stressed they may have to be changed. But then when but before changing certain actions can be done on it.

So, that we need not change and it will run up to this. Now while running it that means sometimes you will have to give oil for the lubrications you will have to give well for the driving power and sometimes you will have to do the cleaning and all operations. So, from the beginning to the end the whole life cycle certain operations are done and the cost is there. You need to do a plant maintenance. So, that the overall life cycle cost can be reduced.

So, that means if you do not maintain or if your maintenance means making a system or a component to work to its desired conditions giving desired output consuming the specified amount of input in the term of energy or manpower whatever it is. So, did if that is the thing as a maintenance is to do it to go running it in a smoothly. Now what exactly it does that means if you are doing maintaining well the machine will not be down or there will not be downtime of the machine means machine is always up time.

And that one when you will be doing a little bit more studies of operation research or more economics engineering economics will be getting a term call the machine must be available that availability. After that once it is available that means machine if you put on that exactly to start it will start, it is ready. But when it is ready it is supposed to give say a particular thing it is supposed to take a in a scoop say 10 meter cube.

But it is giving in a scoop that only it can load the say only 7 meter cube because maybe inside something has gone wrong or when it is stacking over there because of the vibration some material spill that means ultimately the transferring is giving only say 60% or 70%. That means along with your availability another important term which you will be coming into cross, you can note it down that is called capacity utilization.

Now that your uptime can be maintained and downtime can be avoided and that capacity utilization is enhanced. So, that your production schedule is maintained. If their capacity utilization that is whatever its capacity to work if it cannot work up to that capacity that means also your system is not well maintained. Then another thing is well it is a working and as per the design is it is such that there will not be any untoward incident.

You maintain in such a way suppose you are having a machine it has got a walkway. Now that walkway was having suppose some crack or by because a rock fell down and there was a damage and then ultimately it was just some bolt not has gone out. Now if you do not repair it or if you do not maintain it to keep it set it to again as it was originally someday somebody is leaning on that as because it has already weak.

It fell and then the person may fell down after that from the walkway. So, that means you will have to maintain to avoid injury. It may so happen, suppose your in a plant that where you are walking by the side of the gearbox is there, at the time of filling oil into the gear box, some of the well onto this walkway. And then you are just you left it (FL: From 10:37 to 10:39). But at that time if somebody sleeps over there, he may fail he may crack his head.

So, that is why that by proper maintenance that means you will have to maintenance one job is to be kept in a clean and then very perfect conditions. If it is not clean it may lead to your injury. Then your machines, that is your asset, asset is anything which has been introduced into your system for carrying out the operations for a profitable reason. Now this that asset may get damaged, it may not be able to use it.

So, that is why by doing a maintenance you might have heard recently that there was a building collapse in Delhi and many people died. That means that building has never looked into that what type of problem may come and there were never a maintenance work was carried out because in a maintenance one important word which is coming is monitoring. You maintain only that is you monitor what is going on.

If it is that is strength, is it is okay that it is using in a proper way its performance are okay. That monitoring is an integral part of maintenance whether you do your visual inspection and visual monitoring or you do a instrumented inspection and instrumented monitoring. So, that is why you exactly avoid the damages to your asset by properly and timely actions taken on it. The other thing is enhancing the assets life.

That means if you properly do the things that asset can be used up to its total life. Otherwise, you will have to do a premature failure and you will have to change it. Then one another thing is there in whatever way you are working in your plant ultimately you are taking certain input and then you are going to give an output. Now that output should be safer. Now in some of the plan it may happen that exactly in the processing.

If your things are too as a when you are producing at that time if you are where you should create some particular size of lump but how what it is doing. It is producing more powder because the machine exactly do a lot of vibrations over there. When it was preparing say some pellets that pellets crash and then lot of. So, in the end user when he is receiving then it may give lot of dust at his environment which can be injurious to the persons working over there.

So, that means by not properly maintaining your system you may give problem to the end user also. So, I think it is enough I have said that what is maintenance and why in a plan that maintenance is required is known to you.

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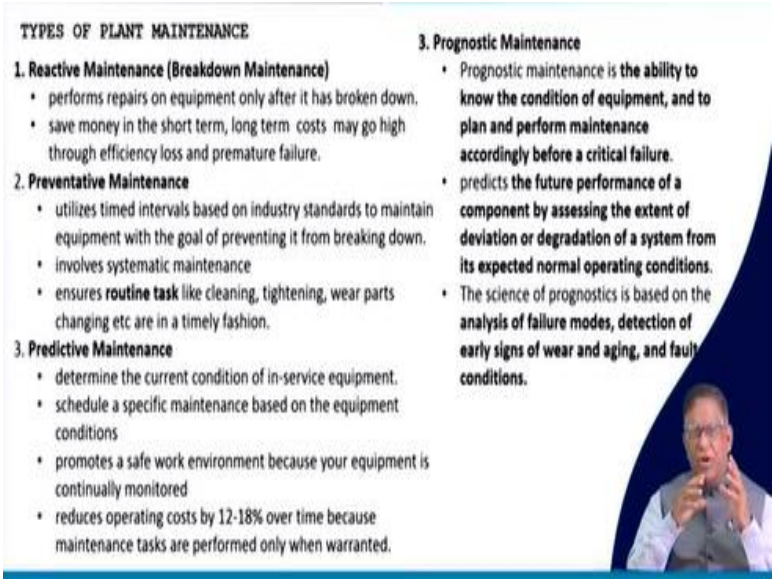

Then what type of strategy will be taking that in your plant that how you will do the maintenance. That depending on that there are different type of maintenance system. Sometimes we say what are the different types of maintenance system or sometime we tell that what is the strategy of maintenance? One thing is our reactive maintenance sometimes we say it is a breakdown maintenance.

We do not do anything anytime; you perform repairs when the equipment only when it fails down. Example is you never looked into that what is the condition of your bicycle chain you many a times do not see also the that conditions whether that exactly how smoothly the bearings of the cycle is working you never oil it. And when you see that lot of cracking sound is coming or when you find that the chain is getting slipping while you are riding.

At that time, you go and take some maintenance on your bicycle. There that was but some people are there they will do a preventive maintenance. So, that before any failure comes, he will look into it every day you will be doing your putting oil into the machine then he will be just seeing

that things go smoothly. He will be seeing that weather yes ok that the you will check whether the even a bicycle the chain is having any slack that is.

Or whether that your back rear side rear will need to be pushed little bit so that the bicycle chain tension is proper. So, that is a maintenance, that means in your reactive maintenance or breakdown maintenance you do not spend your time, you do not invest your time. You do not invest in buying some oil and putting it over there. By that you are saying ok your cost of operation your cost of using or having that machine is very less.

It may so happen that when if it does not break fine but if it breaks then when you cannot go you cannot in a bicycle case your bicycle chain is falling down you cannot go on time into your class or sometimes while putting the chain up you will be breaking all the black spots on your face. So, that is exactly the cost, ultimately it may be very costlier. Though immediately by doing a breakdown maintenance you can save some money.

Your crusher you do not stop thinking that have a maintenance (FL: From 16:28 to 16:29) this whole stressing plant will be running. But after sometimes when certain if the bearing or that your toggle. You might have seen the toggle where it is moving with there is a bearing. If that bearing has failed then what will happen then for you were not stopping every the two hours for maintenance then maybe the whole shift will go in repairing it.

So, in that way you will be incurring heavy loss that is the problem with the breakdown maintenance or reactive maintenance. In the preventive maintenance they though systematic maintenance and how are they do? They do a routine task, there will be a checklist that is why preventive maintenance sometimes called checklist also. So, if you are having in a conveyor belt drive in the conveyor belt you know that means your exactly you need to check every day.

If any motor is getting heated or if it is any abnormal sound is coming whether there is the vibration is coming additionally whether the tension of the belt is ok whether there is a belt is not slipping all those things are monitored. And then you just stop for doing that cleaning. If there is

any that is your material is going to the return belt over that crown pulley if that when the pulley any material is getting trapped between the conveyor and the end pulley you remove it.

Below the conveyor if materials have got piled up remove it and put it clean so that operations can be doing all. So, that way your preventive maintenance but then came another strategy called predictive maintenance. In the predictive maintenance you do not stop all the time for doing all these routine tests. There maybe it is already the notice tight but thing is that you will have to go and check whether it is not as tight or not that type of preventive maintenance you do not do.

Instead, what you do? You just where there is a if the knot is loose then that particular part will vibrate you keep a sensor over there and then you keep monitoring that how the vibration is coming. Then what they will do? They will find ok and only this bolt there is a maybe by tomorrow or after tomorrow it may become more loose. So, when they have started a trend of getting loose at that time you go and just tight that one.

By that you will be just for the time of maintenance; which earlier you are having say two hours a day you are stopping it. Now you can stop it only for half an hour maybe some of this little bit of checking and all then your machine will be running. So, every day if you increase one hour production time is increased and if a conveyor belt is having a carrying capacity say 5000 ton per hour. That means in a month 30 days about your 150000 ton will be produced additional.

So, you can think of how it will be leading to the productivity by bringing instead of preventive maintenance you go for the predictive maintenance. And in that the overall cost is reduced and it will be your systems are all the time being monitored. Thing is in the preventive maintenance you stopped only for the two hours and you are going checking each and everything whether it is ok or not.

But when the operation is going on at that time also in a predictive system you are being monitoring. So, now it is the operator has got only two eyes but now you have taken sensors of hundreds of eyes can be kept over there on the monitor and the conveyor belt to run it. So, this is

what is called your predictive maintenance. So, you can define that is your breakdown maintenance is running up to the failure you do not do anything when fail you repair it.

Preventive maintenance is exactly you make a checklist and routinely you check and do it for so that your any failure can be prevented, premature failure can be prevented. But in the predictive maintenance they will be monitoring and on the basis of the monitored data they will estimate that when which maintenance is to be carried out and where there is a impending danger. Now this is another thing is they are called nowadays this predictive maintenance.

Or it is condition based maintenance monitoring things were there. Now this terminology that is used often is called prognostic maintenance. That is where the condition of the equipment can be known and you can plan the perform and the perform according to a criteria critical failure. So, that means you are allowing certain things to happen as observed. So, it predicts a future performance.

In a normally in a predicted maintenance, you are seeing that no failure will take place. But here in a prognostic you will ensure that if I operate in this way all that things say after one month also it will be giving me this much of production. So, that is where exactly the prognostic maintenance has got more intensive monitoring. And this prognostic science it is exactly develops what are the failure mode in which way the system can be failing.

Or that what type of exactly that how the bear and aging under what type of fault conditions may arrive. So, this is you will have to be intelligent now to read the language of the machine that how it cries in pain, how it smiles in its good that expertise you will have to develop. Any maintenance engineer who has got this prognostic maintenance or this even that condition based maintenance they have got a direct exactly language they understand the language of each other.

The maintenance engineer knows if by his method of testing that this is the way the machine is speaking.

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Now for that what you need to know you will have to now you know the types of maintenance. If it is a breakdown maintenance on occurrence of the breakdown only failure they will be doing. What they do? They will have to know localization that means where that pillar come this assembly that item will have to be separated and do then reassemble then during that time, they will adjust the things they will see the balance.

Sometimes they will separate out isolate something. Sometimes some item can be changed from here to here. You might have seen that tire change (FL: From 23:33 to 23:37). You can interchange some of the things, change of spheres you can get it from another machines were also you have the kara Burra you can fit it over there, you align look into the align. So, that the things are working in the balance.

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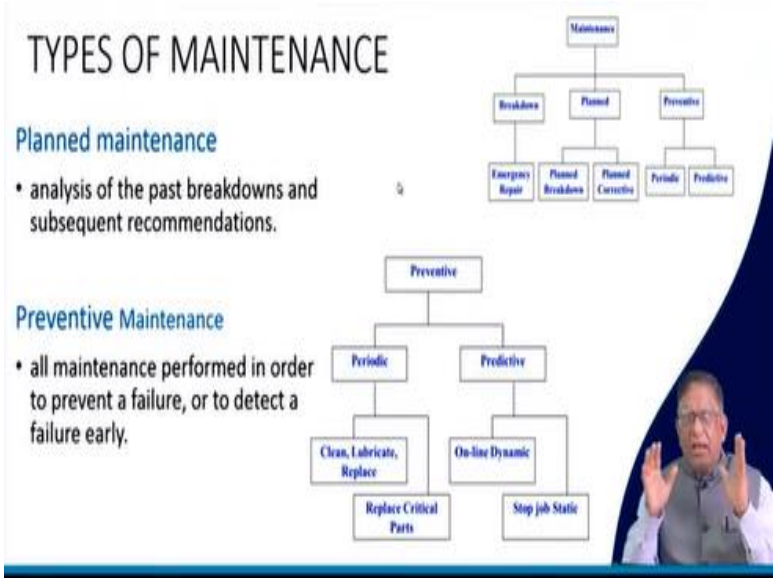

So, this is the way how exactly the things are done. So, as we have said already that their types of maintenance are either a planned maintenance or a preventive maintenance. In the planned maintenance we can plan the routine or the checklist for breakdown or plan and preventive under these three category and here you can go on seeing that in the preventive it can be a periodic preventive, it can a predictive preventive.

It can be clean lubricate and replace job is done, oil line dynamic is done, replace critical parts, stop job static like that you use your some of this terminology you need to learn to put and this will be your specific to a machine or specific to a system which will be varying.

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But say once a problem comes you should go for asking questions that how the machine is speaking. The machine will be demonstrating something it is if the engineer's observation skill is not developed. If it does not know the science or chemistry or the exactly how the work energy and power is related over their machine then he will fail to understand the language of the machine.

So, but before going to what are those languages those are the techniques by which you will be sensing the condition of the machine that is also a part of it. But before that when any problem comes say for example in your system and so whether it is a reclaimer whether it is your some of this your vibrator. Vibrating machines you may use a hydraulic cylinder and what is there in a hydraulic cylinder the piston should give a linear motion properly.

If it is not happening you can ask us the question why? Why is the cylinder do not operate smoothly? Maybe that is inside the cylinder some dust particle has come that means the strainer was clogged somebody may tell. Then you will be asking why the strainer is clogged. It is normally it should not be clogging that means there are some strainer has got some strainer is a screen you have learned that in the screen different messages are there.

So, there your if somebody will tell your oil is dirty. Then your question will be why oil is dirty because that enter into the tank that means your oil was there in a tank it was moving all along through the pipe but then why this oil is again becoming dirty that means it has got something that were from. Why did the dirt enter the tank? Your tank is shield inside that no dirt should come. So, there could be things now you need to check what are the possibility there.

That means in the tank if there is any upper cover or there is any seal or there is any gasket need to check that the physical cause or there could be other things also that while when it is coming through it is you need to see, where it has interacted that oil? Which are the portion it has lubricated. In that portion if the bearing is moving over there whether the dust or dirt particle are getting coming from the different parts inside the machine.

Then if you have found that there was a hole in the gap of that one cause if you have found. Ask another question why was there a whole gap in the tank? Then if it is there then you will have to say repair and during the maintenance work. You have got now a job to be done in maintenance. Then first thing is that sometimes say ok that person who was doing the repair at that time itself it did not fit properly that is why.

Then you will be asking, why was there a repair error? That is again you will find that the person who was doing or he did not follow the rule. He did not follow the procedure. Look into the procedure whether it is stipulated or not properly, what to do? Are you understanding? That means in a maintenance of a system comes when you will be putting your questions properly you will be entering into where and this is a investigative technique all the maintenance engineer do.

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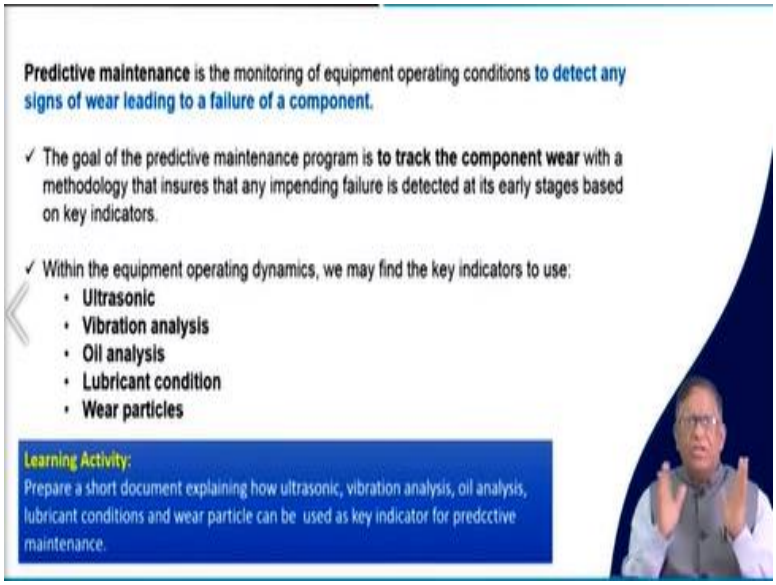

So, the predictive maintenance of that monitor it will have to detect the signs of bear that is leading to the failure of a component. If any component is failing that it will be there. So, that means if the component is failing because of bear or anything, how will you know? That means if the machine is malfunctioning if there is a problem coming your bearing is there is a bear is taking place the bear that is you know bearing.

I think in your second-year classes you have studied about that wherever a soft is there either a ball bearing or a taper roller bearing or a roller bearing spherical bearing different type of bearing

is there. And then maybe there is a hydrodynamic bearing whatever it is that. Bearing when it is there it its job is to get the taser almost that reduce friction and the shaft is rotating inside the bearing.

Now if there is a bear what will happen there will be a different type of sound will be coming? It can become hot; it will become heat and all that thing. So, you will have to get some key indicator that means where any malfunction or failure is there how you need to know. Now there are certain tools like you will be saying that language of the just a doctor they test these things with a stethoscope you have seen. They have got the thermometer.

Similarly, your as an engineer if you are maintaining if your machine is having a disease if the machine is ailing you will have to also have your thermometer you will have to say you heard there nowadays they put a catheter inside and they take the image of your in the things. Same thing you know that is called a horoscope you will be using your gearbox oil whether there is a it is oil is dirty or properly doing, sand one tube with the optical fibre tube with there take illuminate it take a scan and then find it out.

So, like that in the gearbox you can enter into and see over there. Similarly, you can put ultrasonic that is your high frequency your acoustic waves are just taken out from there and you can find out how it is working. Vibration is done that your oil, oil is a heart of a any machine just like our in our body we have got the blood. If in a big machine when the stacker reclaimer there you will find there is a lubricating oil.

Because there are so many if you take a bucket will reclaimer that whole thing is just swinging. We talked about it is swinging that means it is having standing on a bearing. You have seen the bucket wheel swing moving your conveyor belt is moving wherever is moving there are lot of your rotating parts are there. Everywhere you will have to do the lubrication that lubrication oil that is why in the machine there will be a tank.

And from there automatically exact amount of oil will have to go over there. So, that is why in any machine that oil and hydraulic oil and the hydraulic circuit is very important. Now that oil if

it is having any problem then your machine will be problem just like your blood. So, you need to do your anything doctor ask you give a blood test you go to a maintenance engineer you say. What is the well oil contaminant cycle (FL: From 31:41 to 31:43) pollution.

They will start this oil analysis. From the oil they will find if engine oil you might have heard in the engine oil if lot of debris are coming means inside that engine your car engine when there that your fuel is getting burnt. At that time, you have seen you have studied your two stroke and four stroke engines there. When it is inside the inside the cylinder when the piston is moving if that oil is having this contaminant, then if a molybdenum is coming that means you will know.

That means there is a on the liner that is a liner is getting damaged. Then if the liner is damaged then what will happen that you will not get the fuel properly burnt. You may find that exactly your fuel you have given. But thing is that air is insufficient or air is more and then this your the combustion is not taking properly, lot of engine problem will be coming over there. So, that oil can tell you about the condition of your engine.

So, here one learning activity for you. Prepare a short document explaining how ultrasonic, vibration analysis, oil analysis, lubricant conditions and bear particle can be used as a key indicator for predictive maintenance.

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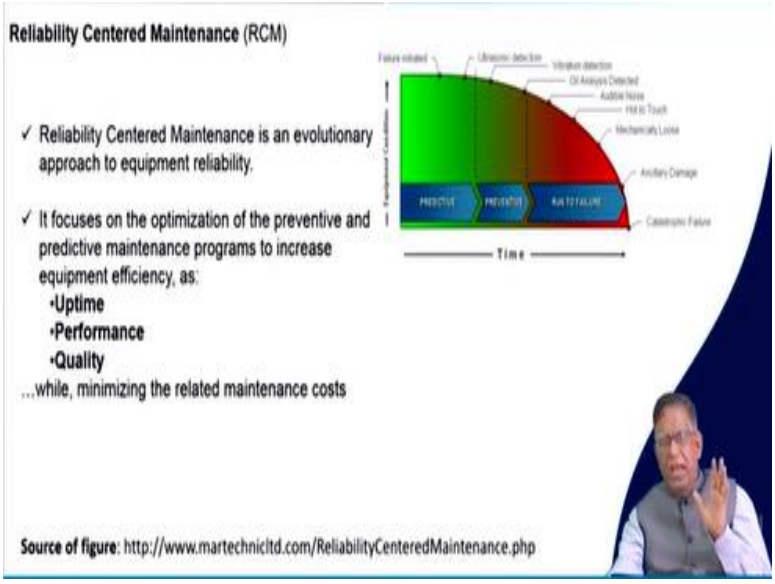

Then you will find that your reliability centred maintenance is another that is you calculate the reliability whether this is exactly it will give it our that up time performance and quality will be reliably will get it or not. For that they calculate the statistics of the this whole machines. How it is working? Different key indicator they do that is your that whether in a predictive maintenance they will be calculating out whether the ultrasonic detection vibration detection.

All parameters they collect and on the basis of that current method they can calculate. If I want to work in one month back; this machine will still give me the performance.

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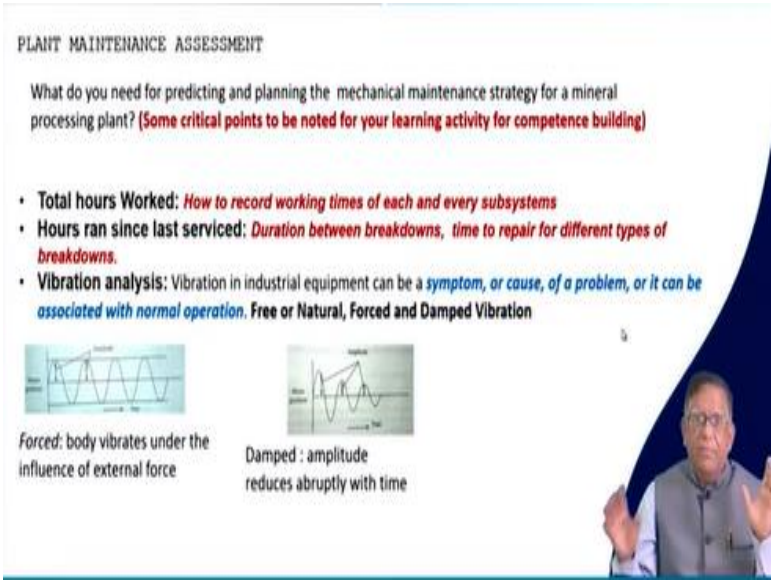

Now that is why the planned maintenance assessment it requires exactly what you need to know what you are going to predict. So, some critical points to be noted for your learning activity for competence building that how you do the prediction and that is your the maintenance strategy you will have to study little bit. Then total hours worked, how to record working times of the machine that is whether this is the type of performance it is they doing you will have to measure time.

Then how much hours since last served you will have to monitor that means I have done a repair after that again sometime it has failed. That from this time to this time how much time it has taken. If between to repair the time is very long that means you are doing a good job. But if your

just you have repaired yesterday, today again it failed, tomorrow again it will that means after to failure time is getting very short that means your maintenance is not proper.

So, like that things you will have to find out those data from that you can take a maintenance decision. And to do that the vibration analysis and vibration study is there. Here again I will tell that you may must be knowing that the different type of vibrations the force vibration, free vibrations. If you take a spring and then they hold it will be start operating that is a free vibrations.

Now if you keep a damper then your vibration starts and it will be damping down that is your damp vibrations.

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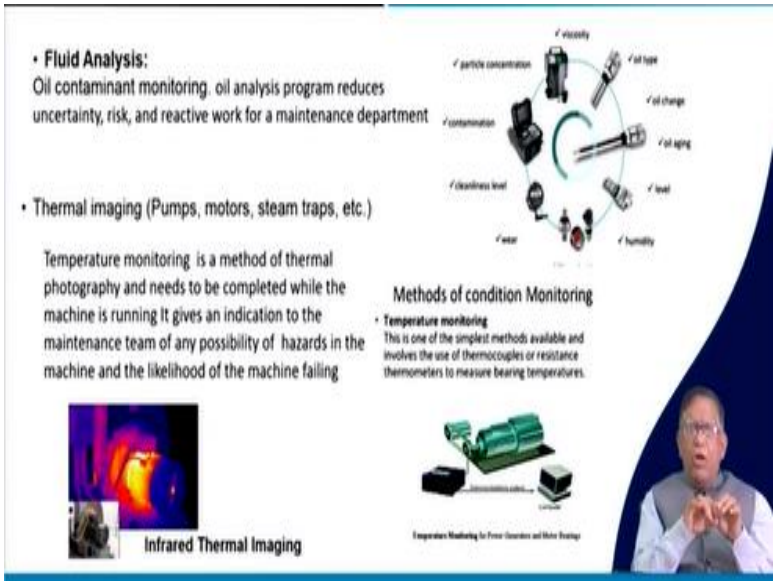

Now this vibration analysis is important. Similarly, the fluid I told you that fluid analysis will be giving you a lot of that is your you need to know that lubricant and oil which are being used their viscosity, their particle concentrations, how much foreign particles are coming over there, what type of contaminations, what type of molecules have come over there, what is general cleanliness level, how the machine is bearing takes place.

All different parameters are determined to do this fluid analysis. Then there is a thermal analysis in which they monitor the temperature in a particular pump motor your steam traps etcetera in

different processing plants in your power plants, you will find this. There your mainly where the temperature will be coming in the bearing portions. If that lubrication is not done properly temperature will go high you keep on monitoring the temperature, then you can give that.

Nowadays what is done? They do the infrared that camera they take a thermal monitoring, temperature monitoring when the machine is running you can put the sensors over there. They will be all the time giving and then where it is heating up. And then you can find out if it is a very critical things you are running with that motor and then you are seeing that yes temperature is going high.

Here the insulation may fail, here your that whole motor may freeze when the bearing will be getting damaged. At that time, you can stop some hazard and you can save your machine that is your how the tomography and how this infrared cameras are put over there, infrared sensors are there and take the total thermal image of the machines.

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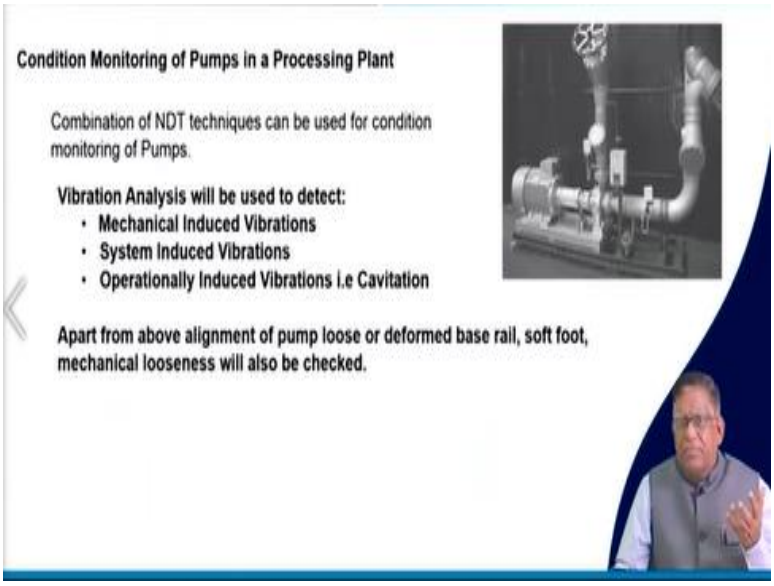

Similarly, that you can find out you should study that how different pumps use in your mineral process beneficiation plan.

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How the conveyor belts? how they are doing and many times you will find in a pneumatic conveying or hydraulic circuit. If any leakage is there then you can do the ultrasonic leak detector. What they do? If a leak is coming then from there because of when it is going at a very high speed over there inside that air is going into that pipe you can get certain centre, high frequency is also now monitored and that acoustic signal will give you what is the condition of leak. So, leak detector is there.

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So, like that a condition monitoring and expert system can be combined together to prescribe that what should be done. And it is your job if you are interested now, we have studied different type of your handling system in a crusher develop a flow chart for condition monitoring of a crusher.

Some of you can take up a condition monitoring of a screen, you can work for say what will happen in an iron ore beneficiation plant.

Or what will be there in a rice mill whether your what type of that your condition monitoring will be there for a conveyor belt installation. Whether that conveyor belt installation is in a food processing plant or it is in a mineral. That basic thing should be same try to develop a flow chart for this.

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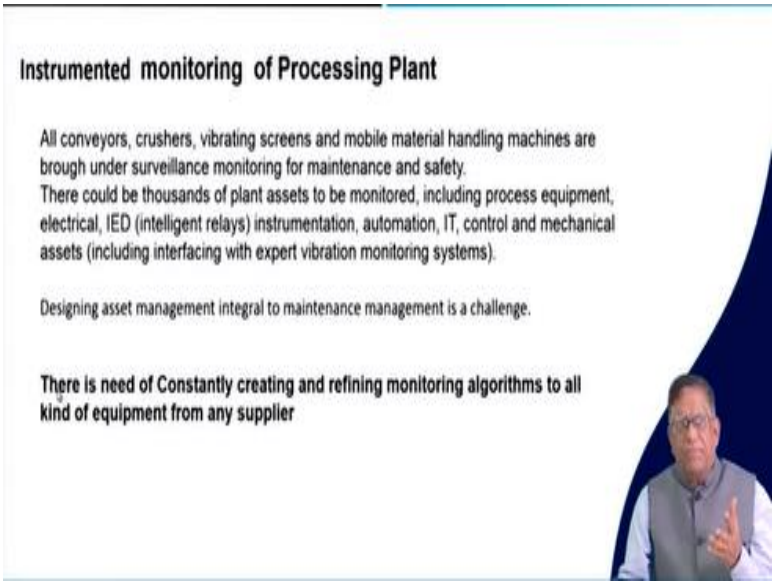

So, that instrumented monitoring of the procession plan can be done by different type of instruments that is electronics is coming in a big way sensors coming and from there how will you develop exactly the controlling equipment and for knowing these things.

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So, it can give to your asset management solution that ultimately your asset lives will be improved. How your that computerized maintenance management systems are now developed. If you go to the industrial things number of big companies, they say they will be giving such type of systems computerized management, maintenance management systems are available. Very lot of development of your artificial intelligence and data analytics are put into this.

And there are the opportunities where there are lot of start-up can work for serving this our industry. So, you need to go visit plant see over there how the work is going on.

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So, that is way you can develop your expertise in this maintenance management.

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So, I have just used, few terminology and general brief introductions has been given and detailed studies of various tools and techniques are not covered here. But I will be I have started I have given you the passwords and the link to the module page depending on your interest we can bring out topic over there and we can do certain exercise in module which is our teaching learning management systems.

I have given if you are interested join me there but still then we will be continuing these discussions for our next class. Thank you very much.