Mining Machinery
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Module - 11
Lecture - 58
Maintenance of Mining Machinery

Welcome to the our last module, as you have see that our total program of learning Mining Machinery. We divided into 10 module and were all the different types of machinery we have studied. However, we because it is a vast area we have not studied the details of the mineral processing equipment like a and there the last one it is very important.

This mining machinery, it must be used for the purposes it has been procured by the company and for that the most important thing is that how will you maintain your machines. So, in any industry that is whether it is a paper mill, whether it is a steel plant or whether it is a mine. The one of the most important thing of operation is maintaining its system and that system comprises mostly with the equipment deployed or the machinery being used for different purposes.

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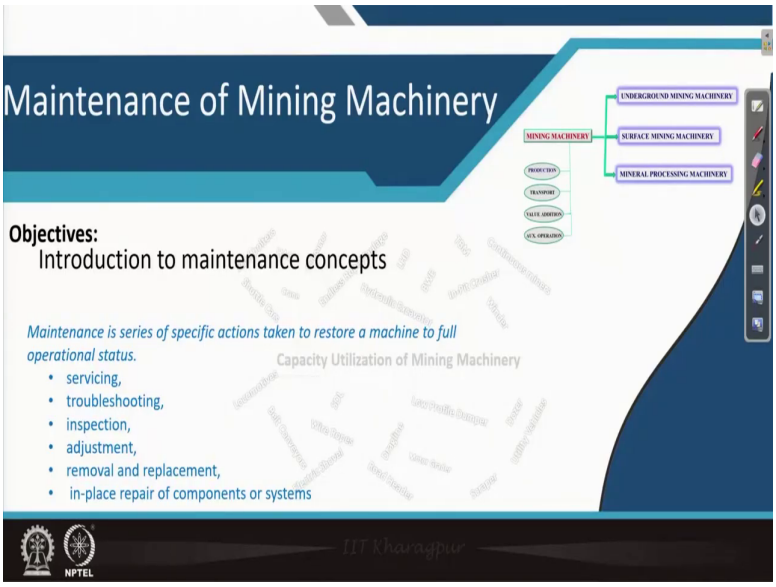

So, this class and subsection class I will be discussing what is this maintenance of mining machinery. So, our we will be introducing basically in this lecture that basic concepts of maintenance. And the as we know that in our mining machinery we have got underground machinery, surface machinery, mineral processing equipment. And they are working for the production, transport, value addition and for auxiliary operations.

If you recall our first lecture where we classified this systems, now during over the journey of learning mining machinery you have seen a wide range of machines and their different components and all. So, now, what is that maintenance is basically? Basically a maintenance is a series of specific actions that are taken to restore the maintenance to full operational status.

Status is very very important. We say it is in a on that is a machine is we say it is a up time or down time; up time means that machine is ready to work, give the service whatever is demanded. So, that is the true for as a building or as or a staircase, the staircase is meant for going upstair. Now, while then if there is a it should serve the purpose of it staircase, so that one can go easily without any hassle.

So, sometimes the maintenance or up keeping these two words are used that is a sometimes that up keeping is associated with while the system is totally in work, no problem. And maintenance often it is called if there is any problem coming, then you are attending it if we were doing a maintenance, but these things need to be looked into the right perspectives.

Now, what are the different work involved in maintenance for whatever this you can see here our all sorts of machines are here our road header, SDL, locomotive, this shovel and all you can think of all sorts of machines. But to keep their services we will have to keep them in operations we will have to keep them servicing; servicing means putting it so that no problem comes over here.

You might be doing your servicing of your bicycle at you are putting some oil on it. You are periodically you check whether there is a air in your tire and tube tire in a tube or not or whether there is a your tire is getting a cut or whether your bell is not properly cleaning, it is not giving the sound that is whether the chain is frequently falling off that is what you do? You do a little bit of that servicing if you keep on doing it this the problem of the bicycle does not come.

Same things you might have seen at your home when your mother does with the sewing machine she also keep always some oil and then some other things you will be changing the that your the that the belt quite often that if it gets that the elongated. If the belt is not in the proper tension, she changes.

I think you must have seen this the maintaining and that up keeping you might have seen how your mother keeps your kitchen that is a proper housekeeping at the same time your that a burner and everything is maintained.

So, it is whether industrial or household you will be doing the servicing. Then comes the trouble shooting; trouble shooting is if something has gone wrong, then you will be finding out suppose you are you might have seen many a times that your TV is there that is your the that pictures are not coming.

You first check whether the this power connected or not, if power is OFF or not or whether tuning is proper or not. Like that you go on finding out what is the what are the troubles and then this trouble shooting things is a to find out where from the fault is there, what is the causes of the trouble.

And of course, you do a inspection and adjustment. In the inspection is observing and seeing that whether everything is or correct or not and then if it is not you do the adjustments. Similarly, you remove and replace sometimes you have seen that some part is it is not working, it is giving a frequent trouble, you replace it.

And, then a whether a particular component or the system will be taken away and another one put and afterwards this maintenance you get some other words also the repair or you might be hearing something called overhauling. I think your bicycle when you take to your bicycle mechanic he say [FL] bicycle overhauling required. [FL] Overhauling [FL] oiling [FL] overhauling [FL] what you understand exactly there that each and everything.

You might have seen this is when you give your bicycle for overhaul what he does? First remove each and everything. Similarly, sometimes when you go to your overhauling for your bike if your motorcycle you are taking over there, what he do? Each and every item is opened up put, it in a stage and then everything is cleaned, washed and then checked whether they are probably or not they check the bearing whether the balls are ok or sometimes they replace

with the new ball bearings brought over there. And they assemble everything give it over there.

That is also a maintenance for increasing the that is your life of the equipment and then what you do basically keeping the machine in the up time; that means, ready to work.

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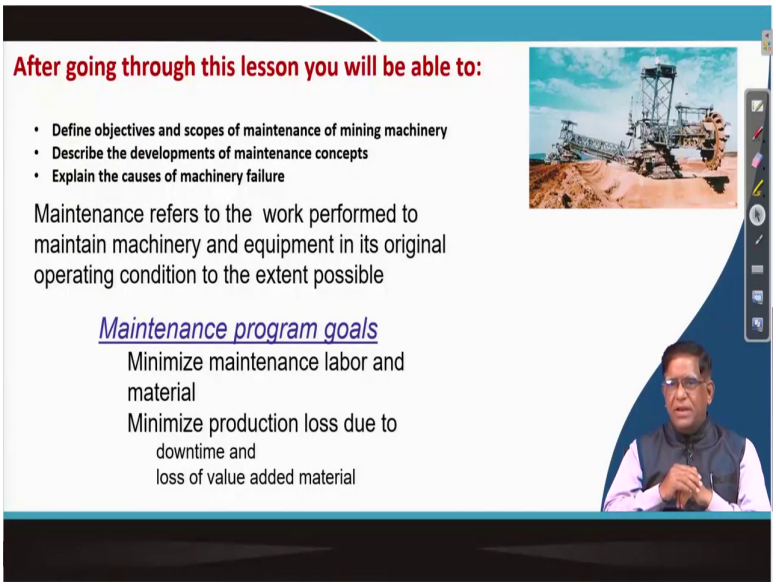

So, in these lectures we will be defining little bit of if I ask what is the objective and scopes of maintenance, I think what you have just now heard me talking from there you can note it down what is the objectives and what are the works done in maintenance. And, then you will have to develop a maintenance concepts this exactly this a how that you your missions will be maintained there are some philosophy, some principles are followed that I will discuss little bit.

And, then at the end we will be telling how what are the different causes of failure of machines, just wear may take place, then you need the lubrications. – What are those things? So, that would be ending up in finding out a new area where you can work. You are as a modern manager of mines, your knowledge is required for every aspects of these high and machines and things like that.

So, you can see here as a bucket-wheel excavator in such a machines where more than forty motors are working a gigantic machines, now that will have to be kept running. You might have heard that this is in the last month such a machines there this boom bucket will boom. Here at this point it collapse it is break fully and it has just fallen down. It has happened in Neyveli Lignite Corporation mines in last week which is a rare accidents in a this type of machines manufactured all over the world.

So, at this moment for all of you who are studying mining engineering and interested in safety engineering, interested in machinery management or you are interested in data analytics in maintenance operations or you are interested in the life cycle costing of or a mine, this area of maintenance management in mines is a very very important area.

So, as a goal what is the maintenance programs goal? It is a as because this you are want to you want to keep a machine operating condition as it was when it was purchased to. That is why the maintenance that is a what is your goal? Your goal is so that you do not spend more money on maintenance that is the thing you want to do the maintenance job, but at a you want to do in such a way that the job requirements become very less.

It is that thing the maintenance people always think in that term. Not like many doctors that if the people are sick then they will be earning more money, same thing is true if the machine is failing then the maintenance people will be earning more money. But, at the same time with money there is a risk and there are also work load.

If that is why if you are in a government company your salary is issued, you must maintain in such a way that maintenance job do not come to you. And, for that you will have to do a

scientific maintenance, properly data driven maintenance, where information based maintenance and that is why we will be talking also may be in a later class that what is a information based for maintenance management.

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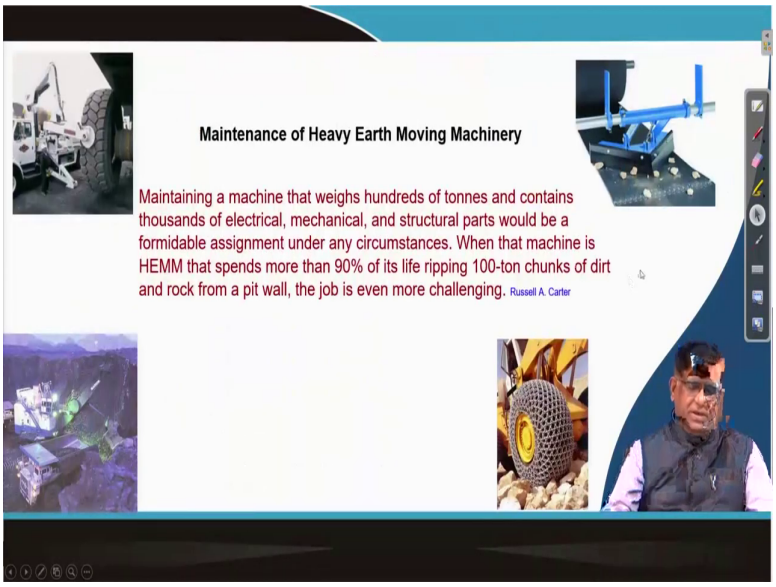

Now, you have seen that maintenance of heavy earth moving machinery one very good one journal at this a editor of a Russell told one thing you can listen to this length sentence. Maintaining a machine that weighs hundreds of tonnes and contain thousands of electrical, mechanical and structural parts would be a formidable assignment under any circumstances.

When that machine is heavy earth moving machinery that spends more than 90 percent of its life ripping 100-ton chunks of dirt and rock from a pit wall, the job is even more challenging.

So, maintenance job is challenging because we are working against nature. You have seen during our discussions different that is a how the tire will withstand such type of rocky things where exactly it can cut the rubber like anything. And there will have to maintain that this a vehicle keep moving, where you will have to do a tire if you think of a 240 ton dumper that tire is such a heavy weight that you need to get a separate machine like tire handler over here to maintain it.

And, then you can see the working condition under which it will be working. If anything fell wrong there to go a maintenance persons to work in that type of mining environment where all these coal phase also may be under fire that whole machine may be just taking a burned coal to the loading on a dumper. So, such type of hard conditions for mining machinery, so that maintenance engineering job is one of the main challenging job.

And, as a mining engineer as a mine manager you can succeed when your all the machines are maintained properly. And, for that whether we are adding a device for example, while studying our conveyor belt. We discuss we remember what is the name of this?

That is a plow, that is a for a belt cleaning device how it is there. So that they that your material this fallen material which is cannot come to the return belt. If it goes below this drum or pulley at the end it will create a lot of problem to the running of the conveyor belt and you will be having lot of machinery maintenance problem.

By putting this device you are avoiding that all those maintenance problem or the failure of the machine will not be coming. So, that is the way in a maintenance engineering provides a piece of additional attachments for valuating or by getting a more services from the system.

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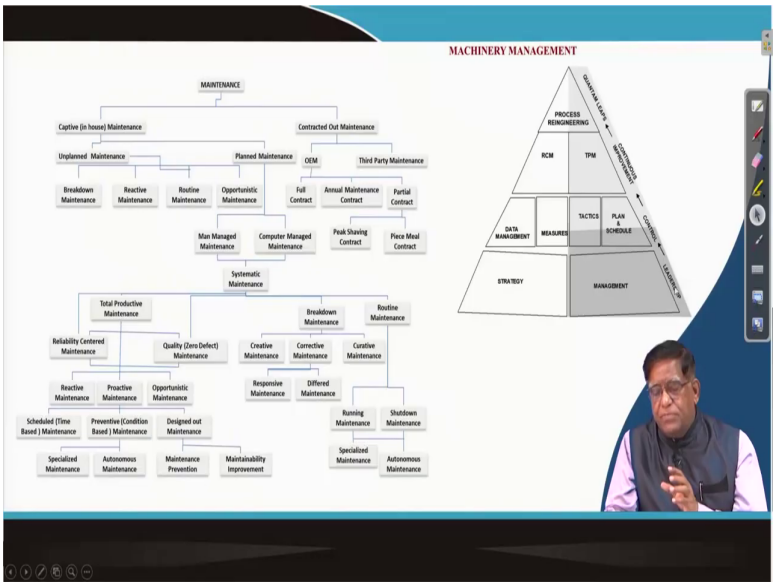

So, here one thing is there that maintenance concepts it developed in a different way. There are so many things over there. There is a it could be a in house maintenance in your industry you can do the maintenance job, you can do it yourself or you can do an outreached or that is you can do it that is your you give a contractual, you give a outsource your maintenance operation to others. There are benefits, advantage, disadvantage all that.

When you outsource your core competency in that area is gone. So, long the supplier supply of the service provider is there you are fine, but if there is a specific type of equipment you have purchased and there is in the market local market there is nobody to do that job.

At the time if you duly on having a maintenance will be outsourced then you will be inviting a lot of problems for future. So, that is why there is always a necessity in your mines or any company to have some of this captive or in-house maintenance.

And, then in a in-house maintenance may be an unplanned maintenance or a planned maintenance. In a unplanned maintenance means you do not do anything over there. There you just wait for if any breakdown takes place, then you will be making all arrangements and then you will service it.

And, then sometimes it is a reactive maintenance you have seen that is ok some something is there for people are complaining all that thing you take up job and do it. But, sometimes there in a unplanned way also you do a routine job that is your whatever is there every day some work will be done in the routine things or sometimes you engage in opportunistic maintenance. [FL] extra [FL] machine [FL], but that is not that is an opportunistic measure, but this will lead to some or other problem.

This was ok when our mine share of a very semi mechanized or very less mechanizations where there, our production capacity was less. We are having only 4.6 meter cube shovel, we are having only 35 tonne of dumper in those days this could be possible. But, today we are having very sophisticated machinery the manufactured by world class companies. So, there we require a planned maintenance.

A planned maintenance can be man managed maintenance or it could be computer managed maintenance. All data everything is changed and then put it over their a system will be their it will be telling and then it will be both the things can be made a systematic maintenance.

In that systematic maintenance, we can have there are many systems called your total productive maintenance. Even your breakdown maintenance can be done systematically; routine maintenance also can be done systematically when we do a planning for that.

And, then this total productive maintenance which could be a reliability centered maintenance. From the data and all you beforehand you plan what is the reliability of that system and accordingly we do with and then there is a zero defect or quality maintenance that can be brought and here there is a reactive maintenance and proactive maintenance and opportunistic maintenance.

Now, these the proactive maintenance means beforehand you take the decisions that could be a scheduled or time based maintenance or preventive or condition based maintenance or design out maintenance. You do some maintenance in which you find that difficulty part that this part will be always giving some problem, you change the design with the help of the manufacturer and you eliminate that problem that is a designed out maintenance.

And, when you do a preventive maintenance there could be specialized or that could be autonomous, that could be maintenance for prevention and maintainability improvement. Similarly, in the breakdown maintenance you take a corrective maintenance are that or creative maintenance. You think of what could be done and there new things or you can do a curative maintenance.

And, then in the corrective maintenance it could be responsive maintenance or deferred maintenance [FL]. Then there is a routine maintenance could be a running maintenance and shutdown maintenance. You preplan that ok, from this month this many days it will be stopped and then you do specialized maintenance or autonomous maintenance.

Similarly, the contract out maintenance can be given for an overhauling ok [FL] machine [FL] contract [FL]. That is the another way of doing then all these things have got another way of doing this maintenance, exactly we need to manage this by tactics and plan schedule and total plan maintenance can come.

But that depends on what strategy you take, how your data management will be done, how you will be measuring the maintenance system and from that how your reliability centric management will maintenance will come which will give a good process engineering.

So, what is there? It is a leadership is giving the control for a continuous improvement, for a quantum leap leaps in the productivity and your downtime will be least.

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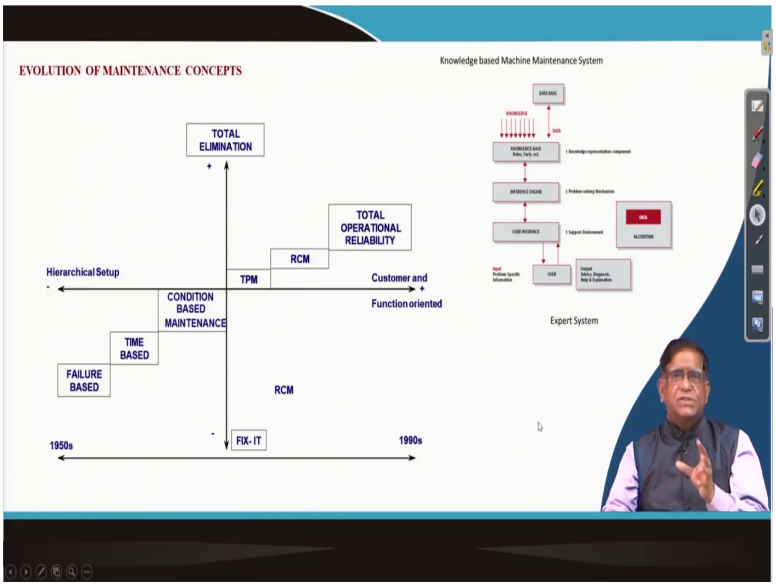

So, overall in the if you see in the industry the concept of maintenance, before 1950s it was mainly a failure based. I told at in those days they are very simple machines, but with then it came a time based that is your they will started doing planned preventive maintenance they started doing and then what they are doing? Every day, every week there will be say 2 hours is there.

They will be doing the maintenance on that and then they started this condition based maintenance by the 1980s later that condition based maintenance started coming. So, you monitor the condition properly by proper instrument and from there only you know that they say in the 80s late 80s a branch called mechatronics came in, that all the machines they are

electronically monitored their mechanical components and then they find out what could be done and that mechatronics today is a developed branch.

And, the electronics and communication engineering instrumentation engineering lot of people work on that, but that is not a restrictive. Do not think they are doing something very great; a mining engineer can do a very good condition monitoring system by their learning because the basic engineering all of you have learned. Then from there is a how you maintain in the field the management development came with a total planned maintenance and then the reliability centric maintenance.

This came in a lot of mechanical engineering development come and in that reliability, centric maintenance there came the concept of total operability maintenance that also in the 90s. By 90s your this the maintenance concept it got measured over there, but today there is called prognostic maintenance. And, there now with the advent of machine learning and that artificial intelligence it has brought that IOT into the machines. That is what they does that exactly they will be monitoring and they will do the self. The machine will itself repair the system.

And, then there came another addition in the design aspects where exactly your the components machines are being some components, do not require any maintenance it will run for the life. So, lot of development has taken over there during the last 5 or 10 years. So, here your that knowledge based maintenance management maintenance system, this need to be developed.

Even now in our country that prognostic or that IOT driven or the data driven maintenance has not come in full form. They are only in the some of the modern sophisticated industry it is there, more than 80 percent of our industry most probably still depending on that whatever the data can be acquired and can locally be done.

And, for that there is a scope of you people to do a journey and the export system where the things are you will have to keep the data, at least identify what type of information must be kept. And, after keeping that information you will be having a knowledge base. You will have

to make a lot of interview with the mechanic with the people who have use with the driver with operator and other things.

And, their knowledge which that by asking intelligent questions you will have to acquire it and put it over there and then you will be having an inference engine. From there you will be finding out what is if then rules will be creating if this happens what to be done and, once you develop that then you can create an user interface.

Now, whenever any operator or any persons having a problem he will be just type this is the problem then the machines they are intelligently they will find out what were the solutions you have kept in the database. And, from there they will be finding and giving the user that yes, you can do over there. And this system keep on going updating and improving over there that type of expert systems can be developed if you study mining machinery well.

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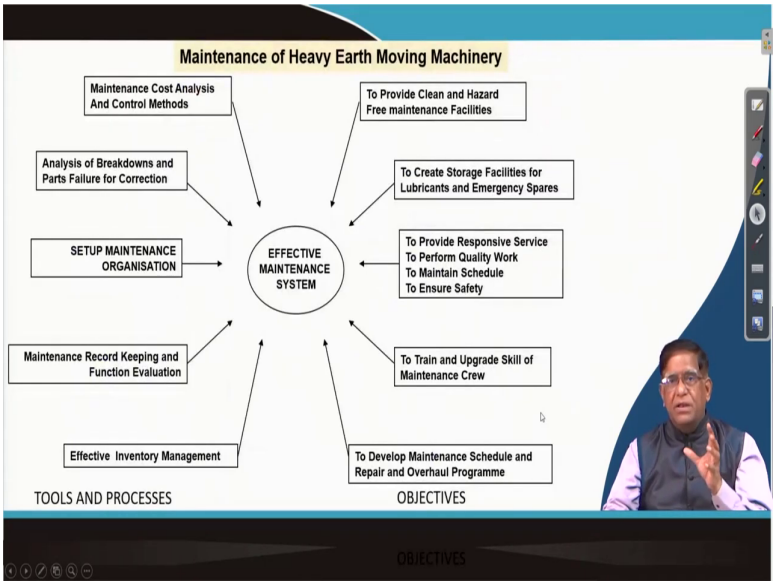

Now, for bringing an effective or maintenance systems your objective should be clear and then to provide a clean and hazard free maintenance, this is exactly your objective. To create storage facilities for lubricant and emergencies spares to provide responsive services, to perform quality work, to maintain schedule, to ensure safety, to train upgrade the skill maintenance people that you will have to keep your own a house also that is your owned resource says ready.

So, these are the objectives and for that number of tools and processes will have to be there that is you will have to engage this effective inventory management, management tools will have to be brought into the maintenance system, maintenance of record keeping because if you do not keep the records you cannot make those experts in future.

So, then your function evaluation, set up maintenance organization, how you will be organizing your maintenance, who will be the top boss in your maintenance. How many parts will be there, who will be supervisor and who will be doing the work, what type of mechanic. What type of electrician you require – that is called here the tools and process. Once these two are there, then in the field you can create the maintenance system.

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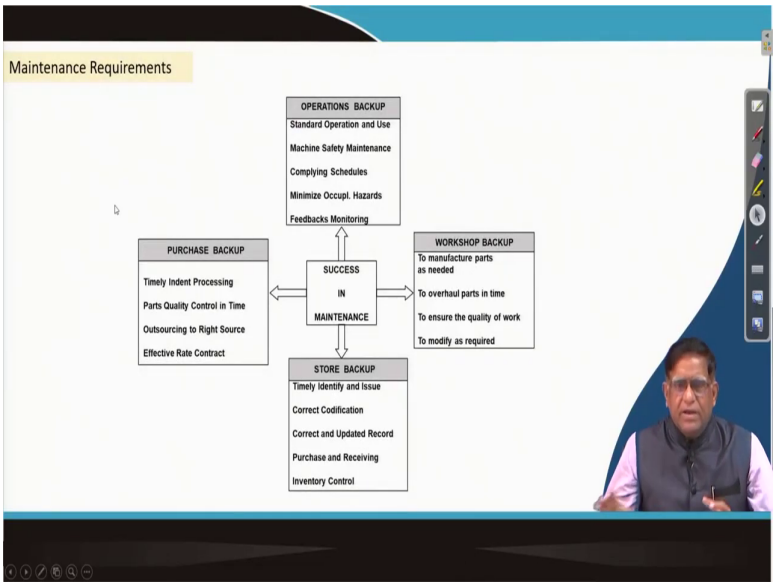

So, then your maintenance will get successful, provided you have got good operations backup, good work shop backup, good store backup and good purchase backup. So, as a student you will have to learn that what exactly is there how to overhaul a parts in time. So, the first thing the basic knowledge how the parts failed, how that exactly the what is the physics and mathematics behind those operations the of the machines how it is working why the wear is coming.

If you teeth of a bucket is wearing fast then exactly how you can do it, how then it will have to be doing a wear facing. If you are to give a wear facing that how exactly what type of surface treatment will have to be done – those scientific things will have to be brought in, then you can do it.

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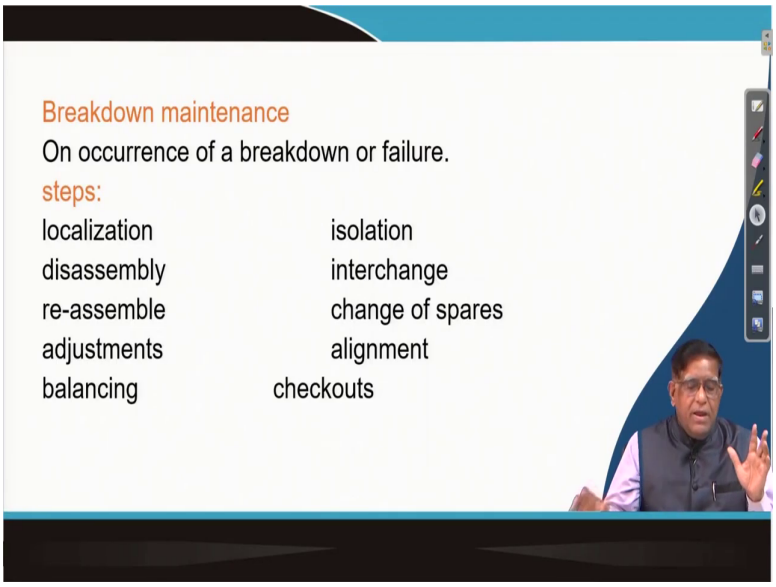

Otherwise, you will have to do this breakdown maintenance in which first you will be doing a localization, you disassemble, reassemble, adjust, balance, isolate, interchange, change the spares, alignment, check out. These are the things how you do and in that you lost time after fitting again you put it then there will be a problem.

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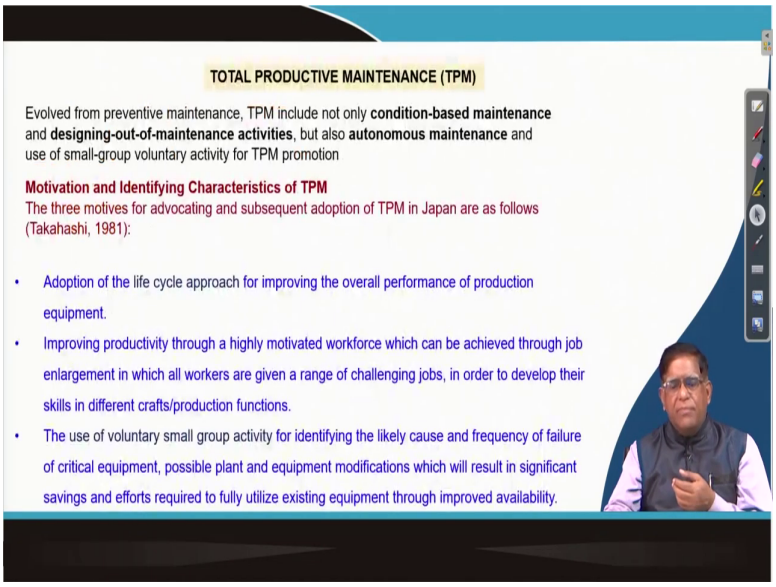

So, as you say that there are different types of maintenance like total productive maintenance there it include not only the condition based maintenance designing out of maintenance activities and autonomous maintenance all commit out. So, design out maintenance is exactly that what change in the machines next making or in the component design should be done that is also brought in, that your these items like your total product that is total productive maintenance which got a very leadership in Japan.

As you know Japan is a very good in providing quality that they brought the movement called zero defect movement and you can see that Keshu and other company that your the Toyota company. And all they got the whole world market and then doing by what they improve the their production systems and their maintenance system or the maintenance pre.

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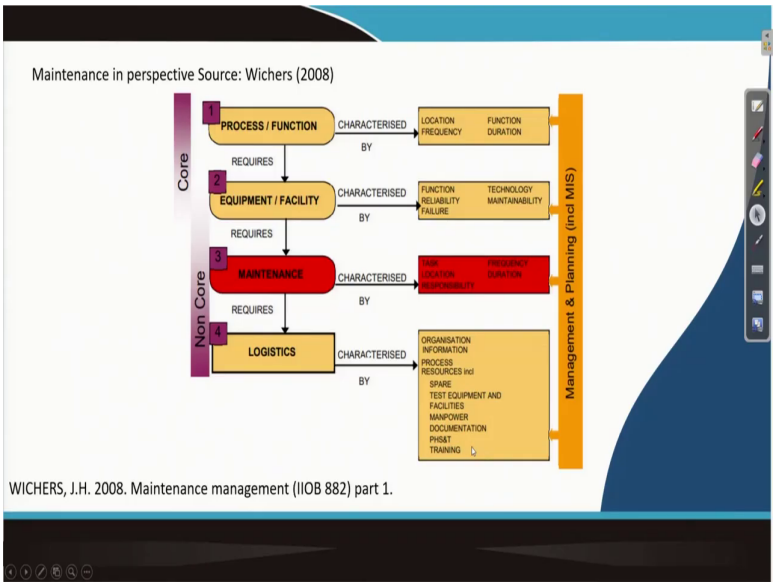

So, maintenance in the that your perspective sources of your maintenance will have to be developed and that can be done exactly the processer functions will be requiring equipment. And facility equipment and facility require maintenance and maintenance require logistics.

And, then everything is characterized by it is some you will have to identify those characteristics and then you will have to do say your that maintenance it is characterized by your task allocation, responsibility, frequency and duration. And, for that your what type of things you will be requiring? You will be requiring spare, test equipment, facilities, manpower, documentations and training.

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Now, once you do that then main thing you will have to see your whether the machine is up time and what is the downtime. That uptime it is that the machine is working during this time, but then the failure occur. After the failure occur you will have to your time to supply the spare on the check out failure detection inspections. Now, this time the machine is now down and again, it has started operating after the end of the repair.

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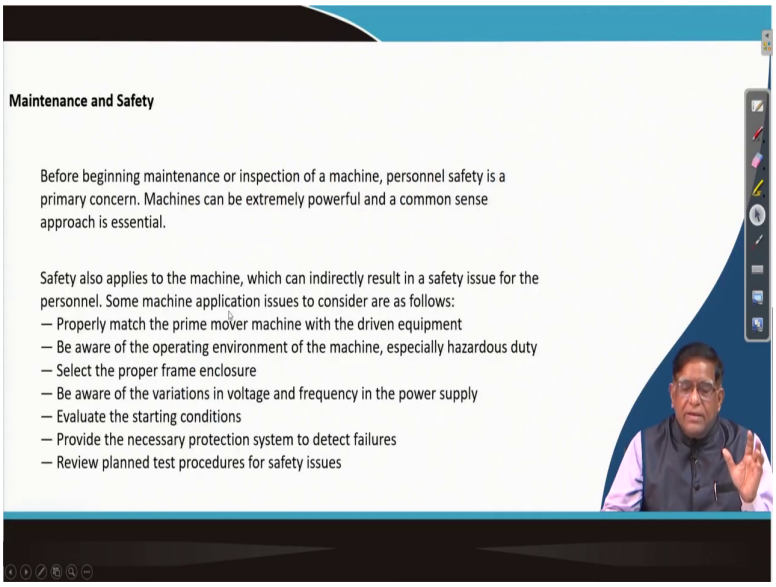

Now, here they keep on noting that exactly that if you can maintain those time, that how much time you have taken for repair, how much time you have exactly got the spare parts and everything ready your system will be properly and then the main thing is that maintenance will be ensuring the safety. If you do not have you are having a faulty machines it is liable to fail during operations and which may lead to exactly accidents to people.

So, that safety of the machine safety of the people it means sometimes the persons may not die, but the if the machine is getting that is a deteriorate further so that you will have to bring more maintenance as. For example, if you are they say the if your tire is not having now that say some nail cames and then your tire got flattened in a car, then you start driving under other conditions.

You will be doing that is exactly your whole tire and tube everything will get cancelled and you will have to buy a new tire, but at the time if you have got a stepney you put the stepney take it over go to the nearest place and then you repair that punctures which are taken by nail say and then what will happen? You will save your tire would have cost about 12000 rupees. Now you have just pay about 200 rupees and your life is.

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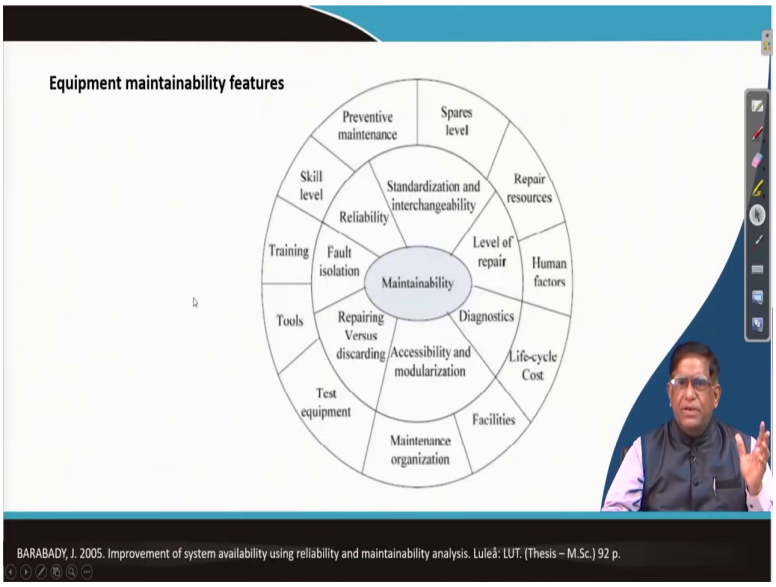

That is where exactly your safety and that safety of the equipment maintenance and cost it will be there. So, one term will be very important that is called maintainability and that can be achieved by different things your what is the level of repair. How will you diagnosis the problem, how you will assemble and modularize the system. How will you repair, how will you do the fault, how you will isolate, what type of reliability will be giving that there will not be any problem.

Then this would require a preventive maintenance, how we have done, what type of skill people you are having, how you have trained your persons, what type of tools you have engaged, what is the test equipment you are doing that whether the things are proper or not you will be testing by means.

Now, if the testing system itself is wrong, by what you are telling that you are ok. That means, keep my examination system itself is wrong, but I am telling that you have failed then exactly by if I have put the correct questions you would have passed with A grade. Now, you have get an excellent grade in mining machinery.

But I have not put the proper questions, can I tell that my if the testing system is not correct that whatever grade and all you get it is just only for getting your degree and things like that, it does not lead to your competency and skill.

So, that is why do not believe on this test examination if it is not done properly and here that is also in your maintenance if a machines is to be tested then the test instrument and test equipment should be proper. Then the maintenance organizations how we have handled, the facilities what we have created, the life cycle cost and others also very important.

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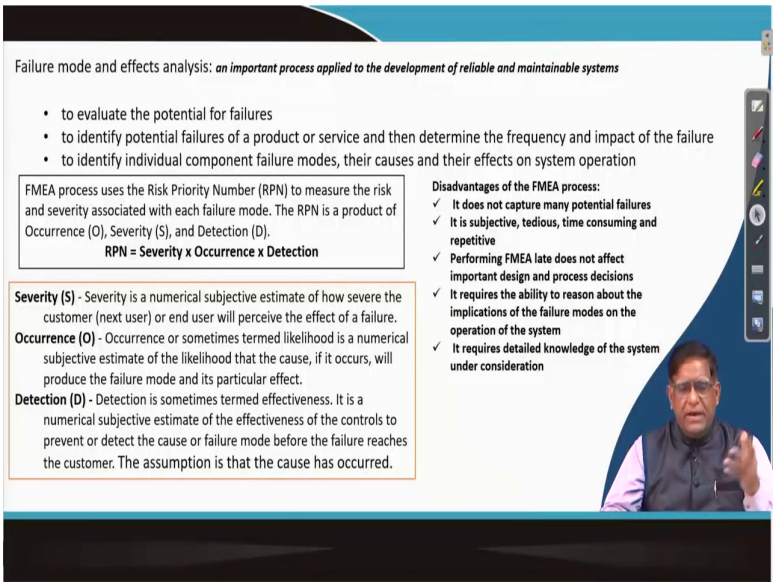

So, that a failure modern effect analysis is a tool by which exactly you apply that how your risk will be done, that is your risk priority numbering is done and then you can tell that how exactly what is the how your the next failure can be stopped. This type of analysis are done by the industrial engineers.

You can take up a very good project work with your fellow friends who are doing industrial engineering. And then with them you can put that how exactly you will quantify, the severity, that occurrences of failure and then detection of failure given a number and then you can get good do these things.

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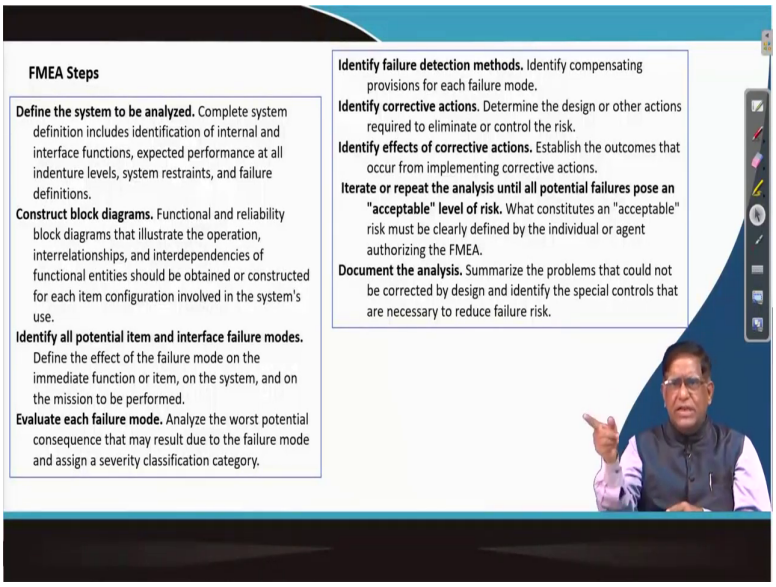

So, there are different steps for the failure mode and effect analysis is you have to define the system. Then construct a block diagram, identify all potential, evaluate the failure mode and then in this is the way that the failure detection and all. I am giving you this as a step you should come forward if some of you want to go to mines ok.

Will I want to study your dumper and then we will find out what are the failure mode analysis and all that thing, do this steps and ultimately you can give a conclusion and the suggestions. That means, if you change your maintenance pattern in such a way next year your capacity utilization will be more and your investment will be good.

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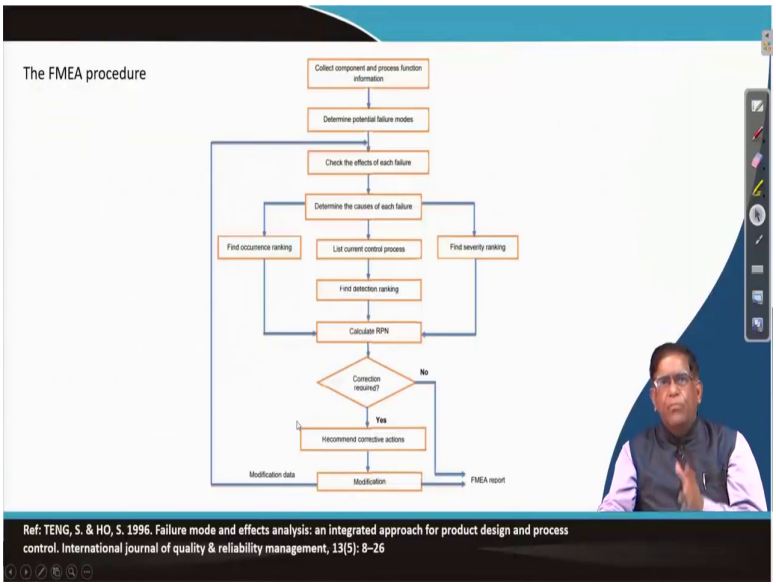

And, today in a computer world you can do these things in a very computerize is in a systematic manner. Try to develop a flow chart if you want to do analysis of a failure of an equipment what will you do it.

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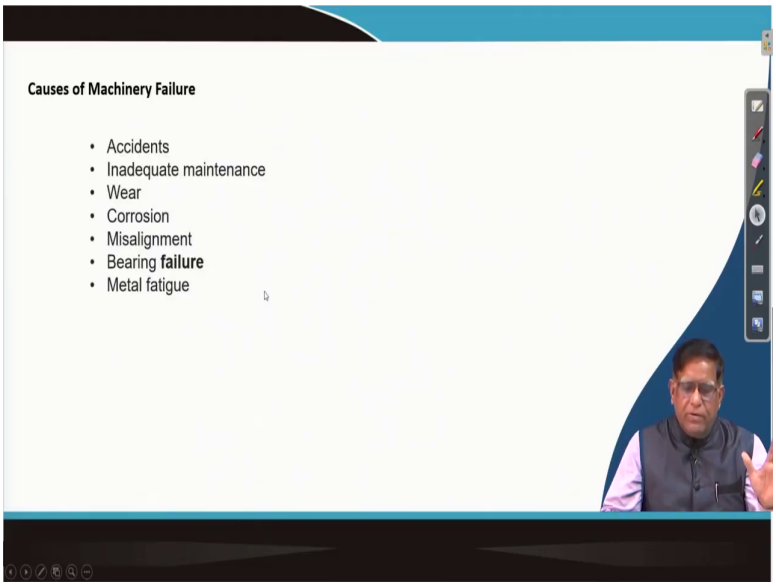

So, the other is this cause of the failure must be identified that whether it is by accident, whether it is because of inadequate maintenance, because of wear or because of corrosion misalignment or bearing failure or metal fatigue. These are the now, you need to study these items separately and for that you will have to find out you just write down these words start, study in the internet find out that.

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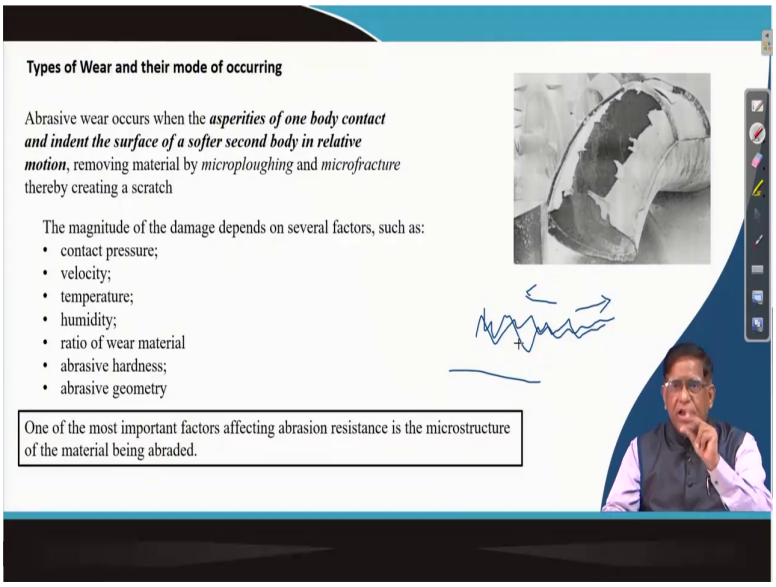

There could be a different type of wear you must have seen this type of pipe will be falling like that. Now, why this type of wear takes place? That is, it could be exactly the wear it takes place because of what happens that is when another surface is there two surface it will be always like that you are some this. Two surface when matching their fine finishing may not be there.

Now, when there will be a relative motion, then what will happen? When this will be moving in these directions then the as per it is this will track and then they start breaking and then when this wear take place then your item become weaker. Say, in a pipe when the particles slurry is flowing that particles will be giving a rubbing inside the pipe will be wearing out that will get thin and sometimes it will get break.

So, these type of problems will occur always and what you can do? Your the damage magnitudes could be depending on that what are the contact pressure, what is the velocity, what type of temperature, what is the humidity ratio, all different factors will be affecting. So, we will have to reduce that.

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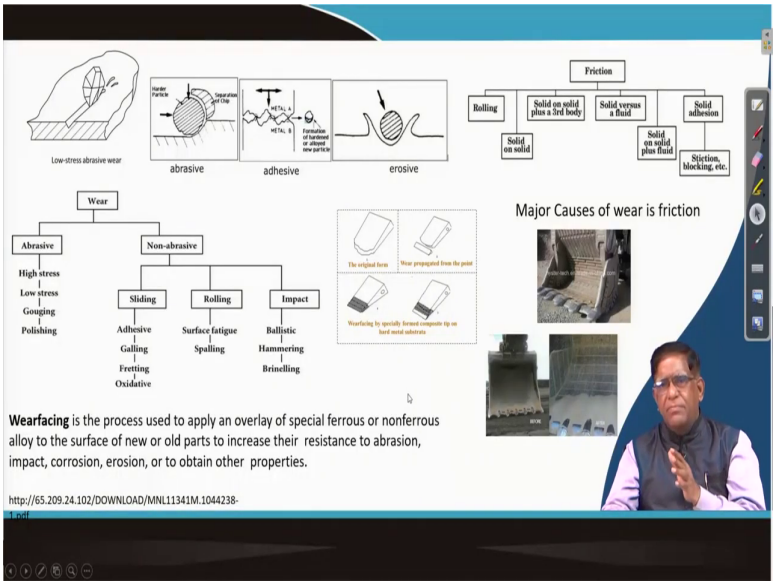

That means, that how exactly the wear can take place by it could abrasive wear. It is just rubbing it the as I said that asperities are planed and that becomes smooth and frail. Then there could be adhesive that when they are moving some particle, it will be attaching to that other particle and when they are moving they are taking the particle also out.

Or sometimes it could be erosions that is wind is coming hitting and taking away, water is coming taking and hitting way that is an erosive. So, different type of failure you can see that how our bucket tricks and all that fail.

Now, the main reason is that is a friction the frictions can be of different type go and study your physics find out what is rolling friction on what is solid in solid frictions. What is solid and solid plus a third body is there, three person particle making a frictions then your solid versus a fluid there is a frictions.

There will be solid and solid plus fluid, then solid adhesion, then there will be sticking to other things and blocking. Try to find out what are the different type of friction, study. If you study one thing and then apply, then you can find that your wear how exactly you can find out many one worn our thing in round your house or around here. You go to any garage nearby you find out what are the worn out parts.

Try to see here what is the abrasive wear, what is non-abrasive wear. In that how that exactly the intensity of that wear has caused. You can finding out and then you can do the wear facing as I tell that wear facing is the process that is this type of teeth. When they will get worn out you put a wear facing some hard surface you are doing it is called braising.

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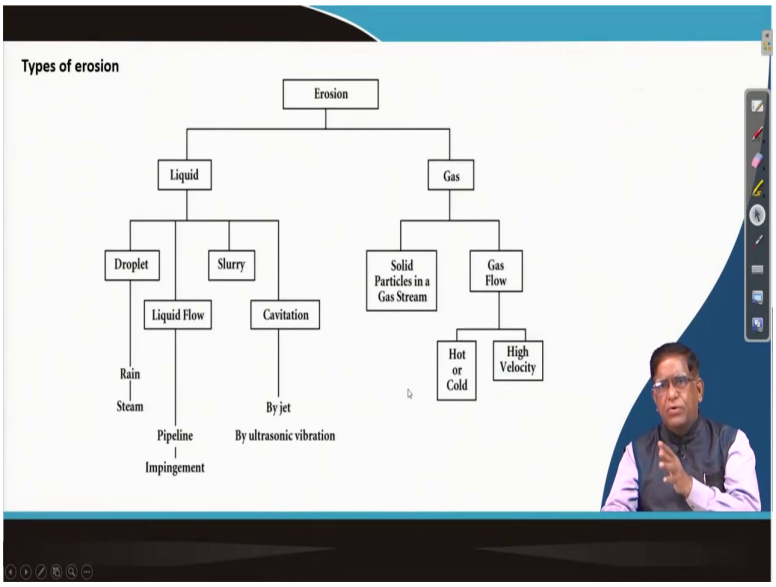

Those processes which you studied in your second year there is the paper of manufacturing process and engineering drawing, if you have neglected that these ideas and all will never come to you and whenever you become graduate or go to the industry you will not be able to do it.

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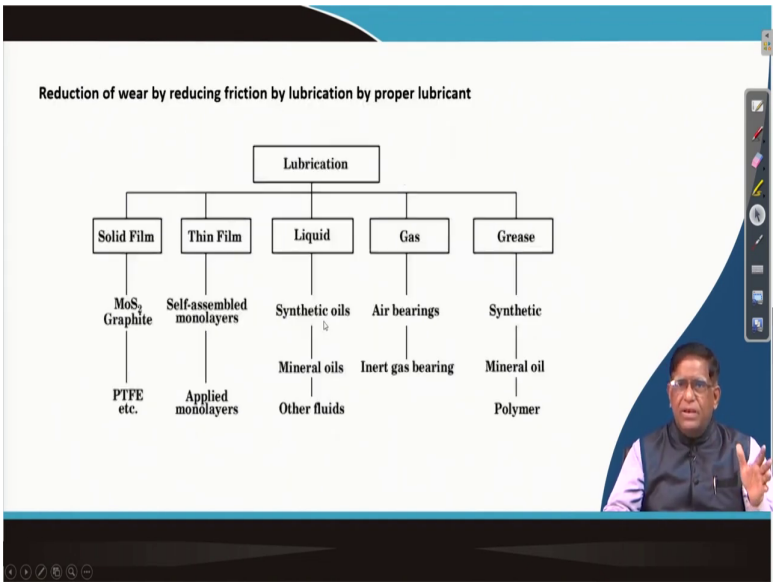

Similarly, there will be all of erosive wear; erosive wear can be in the liquid erosion or it can be gas erosion. There are a number of situations in the mining industry where these phenomena take place and you need to see, but the most important in the maintenance is you always do lubricate, you say whether it is your household small equipment or a big machinery, lubrication will have to be done.

Now, there are many theories and principles, a lubrications has got lot of avenues. Many of you I am sure if you are interested you can do your PhD in country or abroad only on lubrication problem. Because they solve million dollar problems in the world that lubrications wear and tear that can be minimized.

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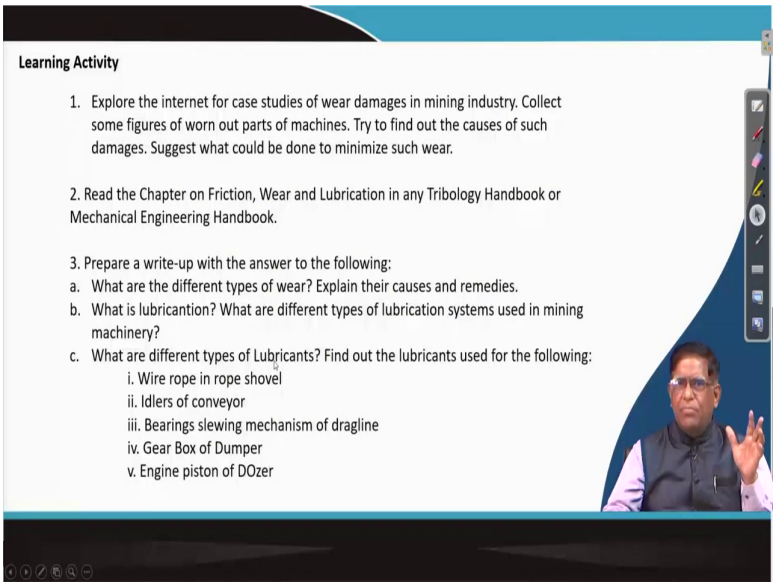

So, what I give you in this brief introductory lectures I want that you should take up this learning activity by yourself. Explore the internet for case studies of wear damages in mining industry. Collect some figures of worn out parts of machines. Try to find out the causes of such damages. Suggest what could be done to minimize such wear.

Then you read the Chapter on Friction, Wear and Lubrication in any Tribology Handbook this as I said the Friction, Wear and Lubrication. This friction wear and lubrication is a branch of studies called Tribology. So that and then all these things when this tribology is attached with it is economic part with economics and data science when it comes with tribology along with finance. Then it is called a subject called terotechnology.

So, you will start in the searching in the internet the word terotechnology and you will find that what exactly a lot of works to be done by the mining engineers, mechanical engineers and

this our the service engineers. So, prepare a write up with the answer to the following question what are the different types of wear, explain their causes and remedies, what are what is lubricants, what are different types of lubrication systems or systems used in mining machinery.

You try to develop your own item and what are the different types of lubricants and you can find out that what type of lubricants are applied in our wire rope in shovel or the in the idlers of a conveyor or bearing of the springing mechanism of a drag line or the gear box of a dumper than engine pistons of a dozer or I mean the lubrication lubricants in your motorcycle or an a Maruti car.

You can find out this type of things and that will exactly give you and lead through the world of the maintenance engineer or a professional engineer. Without knowing maintenance you cannot become a professional in any field.

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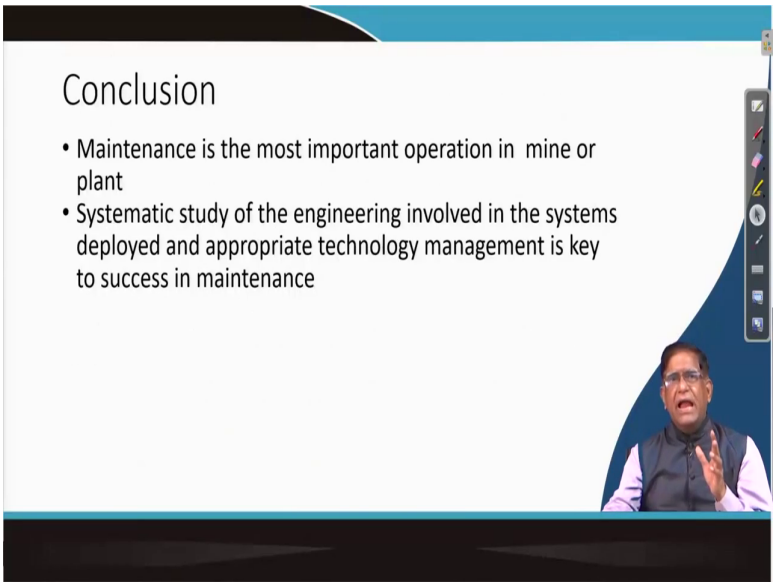

So, maintenance is the most important operation in mine or a plant. Systematic study of the engineering involved in the systems deployed and the appropriate technology management is key to success in maintenance. So, with this, there are lot of materials available in the nets and then in a library you need to read and study that.

Thank you.