Mining Machinery
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Module - 01
Lecture - 01
Introduction to Mining Machinery –Part A

Welcome to course of Mining machinery; I am Khanindra Pathak, I teach Mining Machinery and surface mining at the Department of Mining Engineering at IIT, Kharagpur. First of all I congratulate you for selecting mining engineering as your professional discipline and for this course of mining machinery; because as a mining engineer, you will be the supplier of raw materials for the developmental activities of human society.

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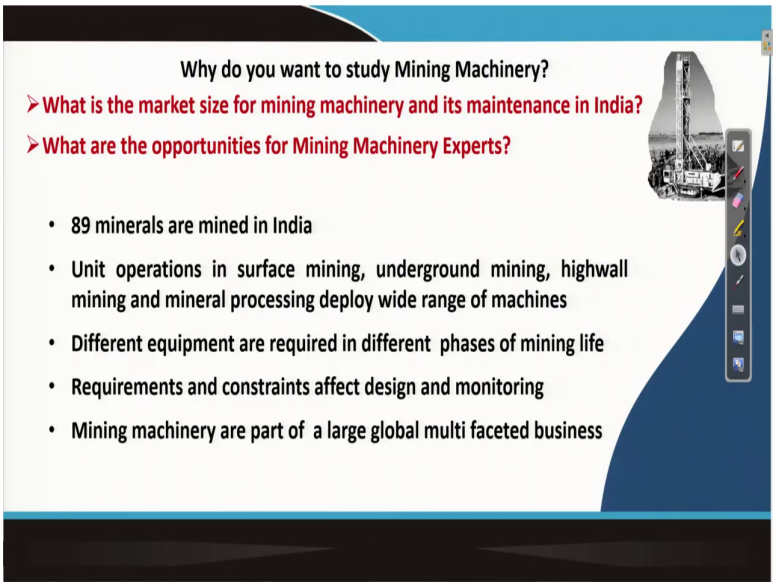

And in this to become a mining engineer, you will have to learn mining machinery. But why do you want to study my mining machinery? You may be interested to know that what is the market size of mining machinery and its maintenance in India and what type of opportunities are lying in front of you, if you become an a experts in mining machinery.

You may be knowing that, in India we are having a large number of minerals; but more than 89 minerals are being mined in India, out of which in certain minerals like coal, like a bauxite, mica all this things we had a global stand in producing in quantity. You may be knowing that, Coal India Limited is the worlds the single largest company producing more than 600 million ton of coal a year, such type of gigantic mining companies exist in India.

And there are all the unit of operations in surface mining, underground mining, highwall mining, mineral processing they deploy a wide range of machineries. And there are different equipment for different phase of mining; because just mining is a temporary operation which has got a initiations and closer. Now, during this life cycle, quite a wide range of machines will be deployed at different faces and they will be requirement not only at beginning of the companies work and the at closure of it, you will have to have machinery.

And, these mining operations they are against nature at many a times to bit challenges of the nature and to retain this maintain a sustainable development around, we will have to make an environmentally friendly mining and that also possess a requirement of different type of machinery.

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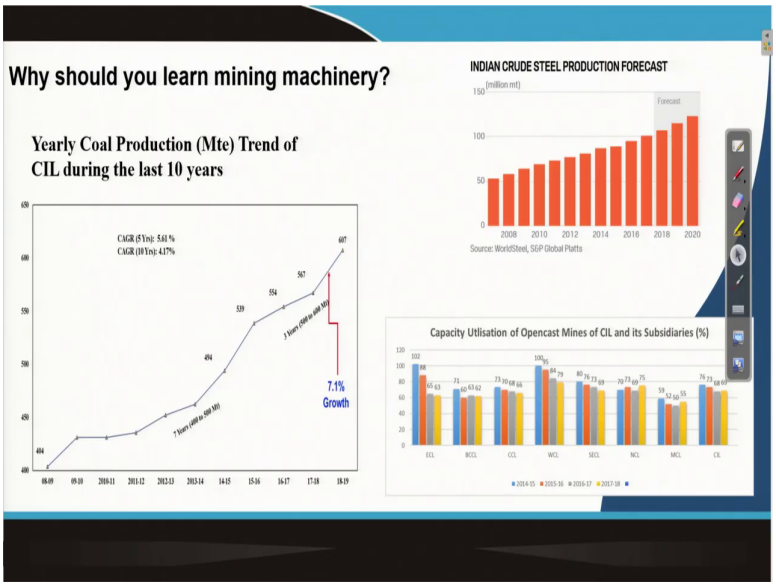

So, this different machineries have been develop over the years of this mining history of more than 200 years and that is why mining machinery is a part of global business. As this slides show you that, even in our Coal India, you can see this from the 19, 15-16 the way the coal production was increasing and before this COVID 19 situations, we were having 7.1 percent growth in the production rate.

So, though at present there is slow down, but still we are thinking that this country will be requiring coal for its large energy demand; though they are will be lot of wind power and solar power provisioning in India, but dependence of thermal power will remain for some considerable years.

And if you see the machines which have been used, their capacity utilisation, as it is seen from the graph here, you can see very well that is a Coal India Limited they are different

subsidiaries; the capacity utilisations of the mines are not up to the mark and there are 100 percent are more than 80 percents are only at few cases.

So, that means the mining capacity can be achieved by proper deployment of machinery. So, there is a scope of deploying this machinery in a better way. And that is not only in the coal; in our steel cases also you can see that, there will be a lot of demand for iron ore. An India being a country having a huge quantity of iron ore deposits also; there will be lot of mining machinery requirement.

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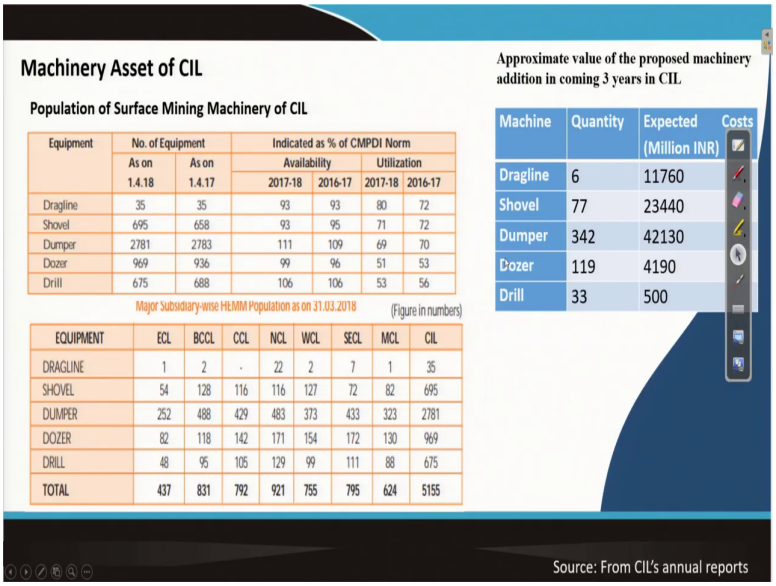

As you can see the assets, mining machinery asset in the whole country; if you see the different types of equipment, you will be learning about all these equipment, what they are the drag lines, shovel, dumper, dozer, drill these are the machines in used in surface mines. If you see their number, that is exactly it is a increased over the years and today there is a more than

5000 such machines are there and there you can see the type of investment that is you are having our in our country, thousands of crores of rupees are being spent on mining machinery.

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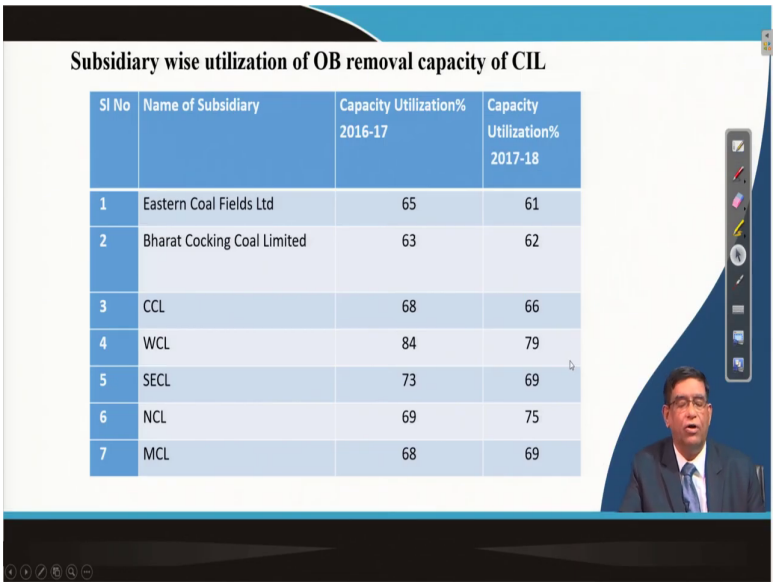

And as a result, these machines capacity utilizations also is seen, it is a only as a in one subsidiary only there is 79 percent; that means what does it show?

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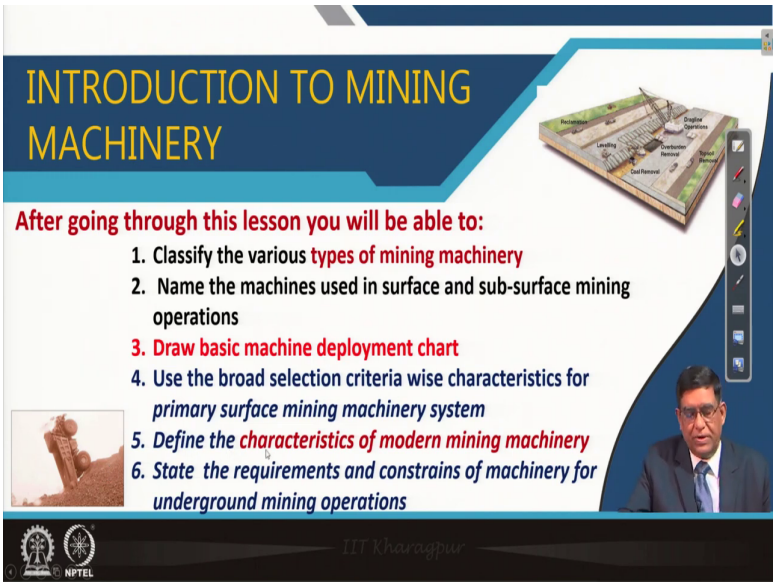

That means, we will have to study mining machinery in a proper way, so that it we can meet a gap; that is how our country can improve its productivity which suffer operations and in an economic operations in the mines.

So, this particular course will be giving, the whole mining machinery course will be giving you a lot of information about all these machinery. But this particular class of introduction to mining machinery; after going through this class, you will be able to there is various types of mining machinery, you will have to classify them, then you will be knowing that what are the for surface and sub surface operations, what machines are used.

And you can draw the basic machine deployment chart; that is for what operations how will you use machines. Also you will be able to develop some broad selection criteria that for

which operation, what type of machines will be selected. And also you will be knowing that what are the characteristics of modern mining machinery.

If you want to study that what are the changes required in our existing machines; so you will have to develop the knowing how the characteristics of machines and how the requirements will be specified. As you can see in this figure that, there is a surface mines with deploying number of machines; as you already have studied the development of mines paper, there you have studied that a deposit is lying there as a coal deposits, over that there are over burden and this over burden will have to be removed.

As you can see here, a dragline is removing the over burden; coal is exposed, shovel is a taking of the material, dozers are making a levelling operations. So, this is a surface mining and while using that, if you do not take the safety; you can seen in that the other figure how a dumper can roll down from this while making a dumping operations. So, that means, there are lot of safety precaution will have to be followed. So, in this paper, you will be learning about these things.

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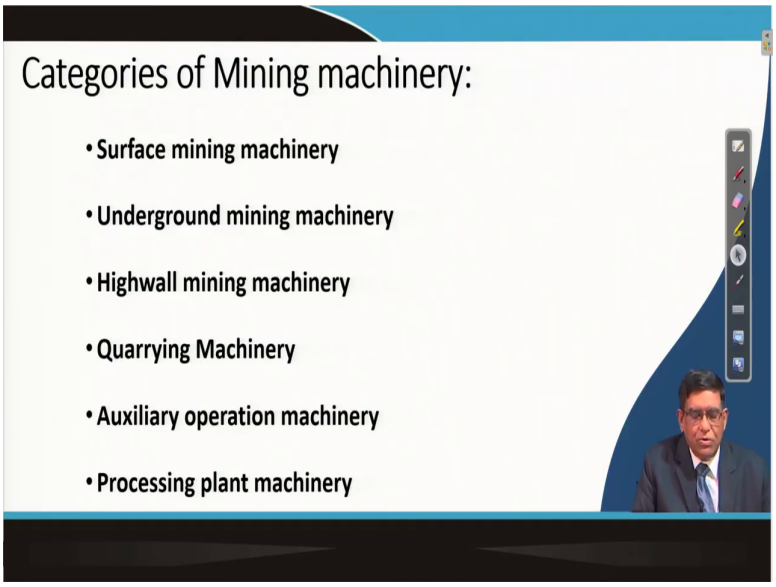

Now, coming to this classification of mining machinery; you know that surface mining machinery and underground mining machinery these are the two broad classification of mining machinery. Surface mining means, you are working under the sun; and underground mining means, you are working entering into the earths and then doing the mining operations.

So, these two operations there is a another one called highwall mining, it is exactly a underground mining from surface. In the sense that is a highwalls means on a after doing a surface mining, the when you are reaching the ultimate feet their the boundary, there also some deposits are there and that is collected, that is a excavated by a specific method called highwall mining. So, we will be studying in this course later on that, what those machines are used for highwall mining.

You will get this quarrying machinery; sometimes you know the stone quarries and that is your quarries for taking root stones and all, there also mining operations. There are smaller sizes machines are used, those are quarrying machinery and there in every mine other than the primary mining operations, there are some auxiliary mining operation related to construction works, civil work. So, for that also you need a number of machines.

Similarly, the run of materials that materials which are exactly blasted in the mines after fragmentation collected and taken up; they need to be processed, they need to be to extract a minerals out of the ore, you will have to first crush and grained and then you will have to beneficiate it, so that the gangue materials are removed, the only valuables are retained. So, this mineral processing is also an integral part of any mining operations and that is why the type of material handling equipment used in this processing plant also come under mining machinery.

So, it is a huge type of different types of machinery; but all machines are basically same, you have got a operating unit, you have got some functional unit, you have got some power source, you have got control and then you will have to operate with this machines, so that you can maintain it, if the machine is ready to work whenever you want. So, that is why there are certain basic things are same for all these machinery; but as a mining engineer, you will have to know the specific purposes how the machines will be selected.

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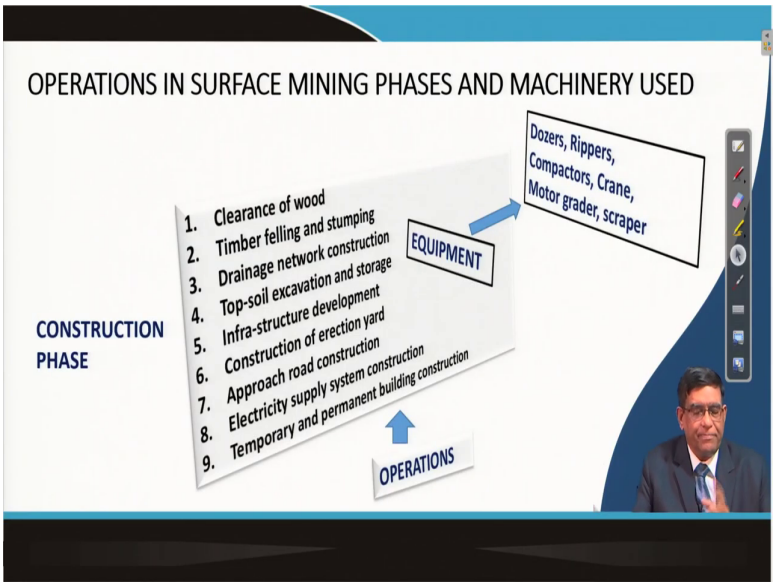

Then coming to this the operations in surface mining are done in different phases. Now, in which phase what type of a machines are to be there? So, if you see we have got this construction phase; that means you have understood that there is a deposit and then in that deposit, you have been getting the list from the government, you have got permissions for mining, then you need to start the mining.

Then these locations may be in a forest, may be in a habitation area; so depending on that, your construction phase jobs will be different. Many of the operations that involve clearing the wood if it is a forest land, then you will have to do timber felling and stumping. You will have to develop drainage network, so that you can do your mining operations properly. If there are some streams or rivers, you will have to divert them.

Then top soil excavation and storage; this is one of the very important environmental job. Because the top soil which is available over there, will have to be excavated separately and stored, because the soil it is it cannot be, if it is lost once, you cannot get, get it again; because it takes millions of years to make a one inch layer of soil over a surface, because this is a process which is take place in a geological time.

So, that is why the and your whole life support is there with a soil; with different microorganisms and different plantations, they can grow only in a top soil. So, that is why that must be preserved and stored. Then they infrastructure must be developed in that area; you need buildings, you need your maintenance workshop, you need canteen, you need road, you need electrical supplies to the system all these things required certain activities.

And then you will have to have the big machines will have to be react there; so facilities will have to be created. And from there, you will have to connect to your neighbouring towns or city and then how your minerals or coal or fuel whatever you are producing that will have to be taken. So, these facilities will have to be created.

So, all these things from electricity supply system to your permanent and temporary building construction required certain machines. And in those machines include your dozer, ripper, compactor, crane, motor grader, scrapers; we will be having a separate class for discussing all these machines, how do they work.

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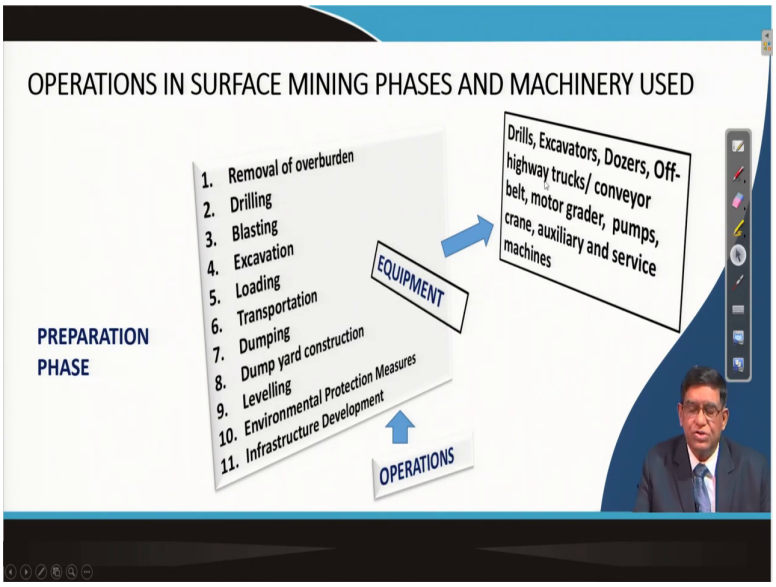

Similarly, when you are going to the after construction is been done, you will have to do the preparation phase. In the preparation phase, the basically you will have to remove the overburden. For removal of the overburden, you will have to do the drilling, blasting and excavation and loading; that is your the to remove the overburden hard rock, it depends on its, sometimes it is a consolidated rock, sometime it is a semi consolidated rock, they need to be fragmented, so that they can become lose to be excavated by an excavator.

So, that is why you will have to use a explosives to blast; now to put the explosives, you will have to do the blast whole to be drilled. So, these operations of drilling, blasting, excavation and loading to a transporting system or transporting machinery and then that transport machinery will take to the dump yard, where it will have to be dumped and then those dump

material will have to be level properly, so that proper there is a site keeping, proper housekeeping is done over those dump yard.

And along with that, you will have to make that environmental protections; that is if you do drilling a hill top mining area, then this whole water from there will be percolating down, so you must see that, there is a proper rain water harvesting facility are created. So, these are the things to be done in the preparation phase. And for that, you have got machines like drilling machines, excavators machines, dozers, off-highway trucks; because these are some mining trucks means, big trucks.

Similarly, conveyor belt, motor grader, pump, crane, auxiliary service machines will have to be there. So, in this particular course, we will be discussing and this construction, operation and maintenance of these machines as well.

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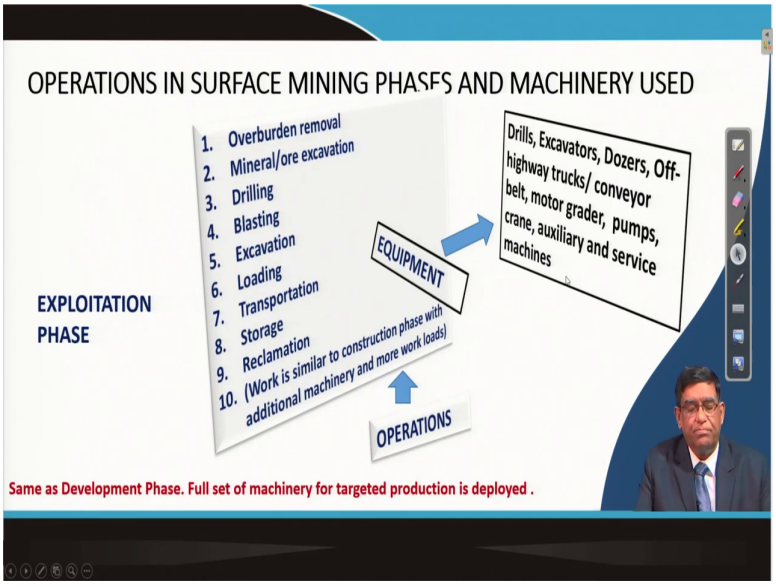

Similarly, in the development phase also, the operations are similar. In that way we will had, we are preparing the whole site to, so that whole productions for which the mine has been planned that can be achieved.

So, that is after the constructions of the basic mined, you will be a doing developing, doing the same operations; so you will be requiring the same set of machinery. Then when your development is over, we start that is now the mine is ready for producing the targeted output per year. So, for that, you will have to do this; that is called your exploitation phase or the main production phase.

Sometimes this word exploitation is very commonly used in mining industry, but it is a production is a better word; exactly we are producing, not exploiting the nature. We are exactly producing from that nature; because we will be again taking care of the nature. So, earlier there were no proper environmental concerns; so people used to say this exploitation, but the terminology still valid.

But there also you see the development or phase and the production phase, equipment's are same only; the number of equipment's will now more, because in your mine is at full pressure to productions, so the production operations may be there at number of places. So, there will be a large number of pleat will be working; when the pleat size is more, you will have to take care of its maintenance and so that there is no road accident and all that things, that means your at this phase, your machinery will have to be managed properly. So, a mining machinery management in the mines is of main job in the production phase.

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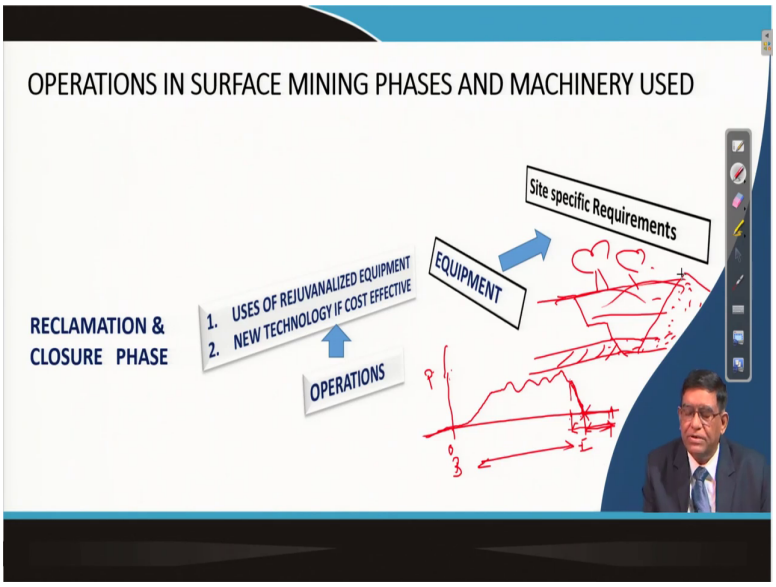

Now, when the production is the mine life is a getting over; that is exactly when you say a mining operation it is exactly, it is starts at a phase when it is there our starting the mine at a time over here, the preparation starts long before that and then at a sometime, the mining productions will have to end.

So, this beginning and end, this is our mining life; in this life, we have seen that your the productions which will be there, initially there will not be productions, then production will start. After that this production, there may be fluctuation; but after that the production will come down and sometimes there will not any more production, but mine life may go because of the, your closing sometimes.

Now, this is a life cycle in which when your doing this a your production is closing down, at that time your this a reclamation phase starts; exactly the mine when you have started over

here, you can start at exactly, this was your deposit line over here. When your excavating this deposit, this void is created; you have kept lot of over burdens will be dumped over here. So, you will have to feel it and then you will have to make this whole tree and then that nature will have to be return.

So, these type of when you are having this air, a mining reclamation phase; means after the production is over, at that time you will be preparing the site again, for that a different type of equipment will be necessary that you will have to see over there. So, now coming to this you can see here that, we have got now different types of machines will have to be learned.

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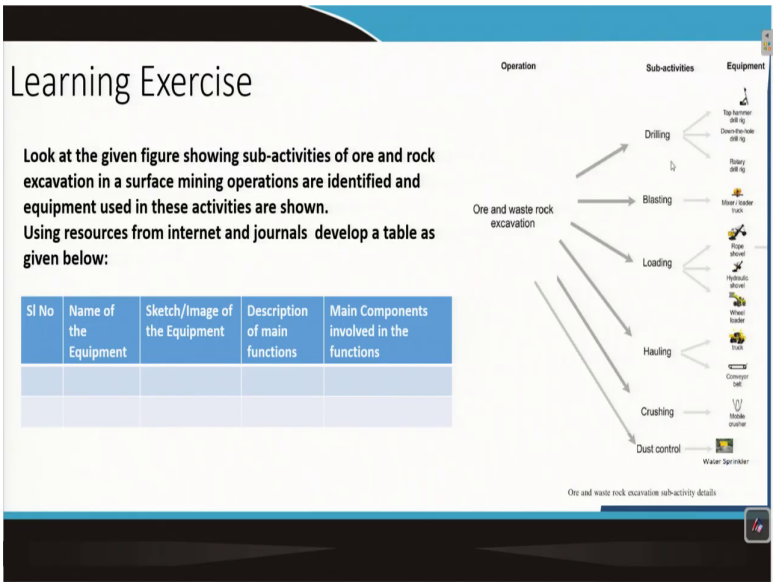

So, you will have to take a learning exercise yourself. Look at this given figure here; you can see a particular operation I have said say, for ore or waste rock excavation. As I said, it has number of sub activities. So, that is your this a drilling and blasting; you have got this a

loading, hauling, crushing, dust control in the mines. Now, while you are doing a drilling, you may have a different type of drill rigs; we will be starting about studying drilling machines separately.

But you must know that, there are different type of drills like a percussive drill, rotary drill, top hammer drill, down the hole hammer drill. Now, what are those different machines used, what are their purpose and how did they work? Similarly, for blasting you will have to fill explosive into the hole, so for that you will be having a mixture loader truck. For the loading operations, you may have that excavators, different type of a excavators may be used.

For hauling, the transporting the material, you can truck or conveyor belt. For crushing, you can use a crushers; there are different type of crushers are there. Now, for the dust control in the mines, you may use the water sprinkler. So, you will have to find out as you are studying the other mining papers from there, what are the mining operations have done and in there what machineries are used; after collecting this information's, try to prepare table like this, name of the equipment.

Draw a some sketch or collect some figures for it and describe the main functions of that machine and then your at the main component involved in that function.

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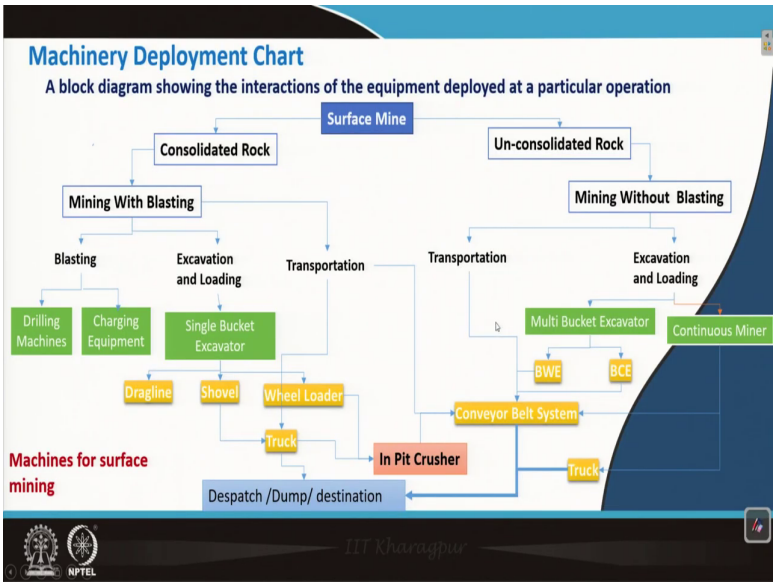

If you do that, this is the way will have to prepare a machinery deployment chart; that means your whole surface mining can be done in consolidated rock or unconsolidated rock. If you are working it a consolidated rock, you will be do a mining with blasting; and you can do in unconsolidated rock, mining without blasting.

When you do it blasting; to do the blasting, we will be having drilling machines. There are quit range of different drilling machines are there, that you will have to collect and study. Similarly, the charging equipment; to do the drilling in the blast hole, charging equipment will be used depending on the type of blasting you select. And then excavation and loading can be done by single bucket excavator in case of your cyclic operations or may be your in a continues operations, they can do it a multi-bucket excavator.

Now, this single bucket excavator which are used with a drilling and blasting, may have a dragline a type of machines or this may be a shovel. This shovel can be electric shovel or hydraulic shovel; that is depending on how it is powered. And there can be wheel loader as a single bucket is there; so also these machines they can give the material to a truck and truck will be taking it to the despatch dump or destination wherever it is to be there.

Now, this transportation job can be done by this truck or it can be done by a conveyor belt system. Now, from this material when it is collected after blasting, this material cannot directly be loaded on the conveyor belt; that is why an in pit crusher is used, this material will go and then they will go the conveyor belt.

Same thing happens in case of your that is a, if it is a loose rock; unconsolidated rock, there excavation and loading can be done by multi bucket excavator. They can be like bucket will excavator or bucket chain excavator. Otherwise there are also a wide range of continues miner; continues miner depending on the manufacture's choice, there are many designs are available, which you will have to study in this particular course.

And that continuous miner can load on to the truck also or it can load on to the conveyor belt. Now, from the other excavator in continues licating, they will be giving it to the conveyor belt and from there it will go the destinations. This is a part, there are other new options and varieties are there. When we say it is a conveyor belt system, that conveyor belt itself has got a quit range of different types of conveyor belt. So, those things will be studying this paper.

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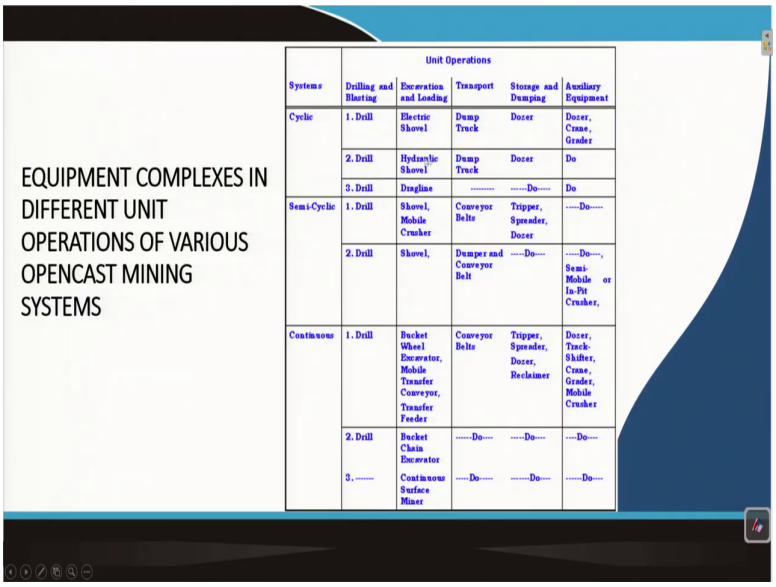

Systems	Unit Operations				
	Drilling and Blasting	Excavation and Loading	Transport	Storage and Dumping	Auxiliary Equipment
Cyclic	1. Drill	Electric Shovel	Dump Truck	Dozer	Dozer, Crane, Grader
	2. Drill	Hydraulic Shovel	Dump Truck	Dozer	Do
	3. Drill	Dragline	----------	------Do------	Do
Semi-Cyclic	1. Drill	Shovel, Mobile Crusher	Conveyor Belts	Tripper, Spreader, Dozer	------Do------
	2. Drill	Shovel,	Dumper and Conveyor Belt	------Do------	------Do------, Semi-Mobile or In-Pit Crusher,
Continuous	1. Drill	Bucket Wheel Excavator, Mobile Transfer Conveyor, Transfer Feeder	Conveyor Belts	Tripper, Spreader, Dozer, Reclaimer	Dozer, Track-Shifter, Crane, Grader, Mobile Crusher
	2. Drill	Bucket Chain Excavator	------Do------	------Do------	------Do------
	3. -------	Continuous Surface Miner	------Do------	------Do------	------Do------

So, that is why you will have to see that, how the machineries are deployed. And as we said that, there are different unit operations like drilling and blasting is a unit operation of mining; there is a excavation and loading is an unit operation in mining; transportation is unit operation in mining. And storage and dumping; that means the over burden or the unbelievable waste rocks will have to be dumped somewhere and the valuable minerals like iron ore or coal they will have to be stored, so that from there, it can be to the end user.

So, for that there are different auxiliary equipment's are also used as a different operations are there. So, the main this unit operations for the machines required will be varying depending on the how this operations are done. In mining, surface mining, operations can be done in a cyclic or that is a the intermittent way or a semi cyclic or could be a continuous. In a

continuous, since there is your the cutting operations and transporting operations simultaneously going without any time gap between that.

In cyclic what is done? The drilling and blasting wherever it is required, it is allow, it is never a continuous job; drilling and blasting is a particular specific job. There you use the drills; drill is the machine by which the drilling is done. So, similarly, you can find that excavation and loading, transportations can be done in a semi cyclic. You can see that, the transportation is done by continuous method that is the conveyor belt and there this conveyor it can be conveyor belt will be giving it to tripper or spreader and then they will be giving by dozer.

So, here you can see the continuous mining is done by bucket wheel excavator and there are other machines like mobile transfer conveyor, transfer feeder these are the machines used. Similarly, there could be bucket chain excavator and continuous surface miner; these are also, these machine is being used now increasingly in our country.

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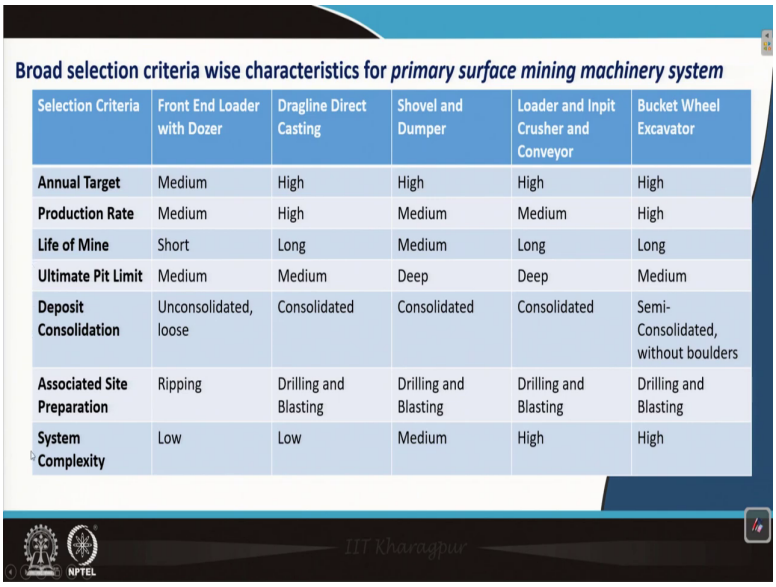

So, the broad selection criteria wise characteristics of primary surface mining system, you can say that the selection criteria are basically annual target, production rate, life of domain, this ultimate pit limit, deposit consolidation, associated site preparation, system complexity. Now, if you use different machines as I said there dragline, shovel, loader, this bucket wheel excavator; you find out that this type of tables are there and you will have to collect it and then study it over here.

So, if you say, if the ultimate pit limit is medium, that is your then your front end loader can be used; but if it is for a deep pit, you will be using in pit crusher and conveyor. Similarly, if the deposit consolidation is high, highly consolidated; there will have to use this dragline or shovel dumper.

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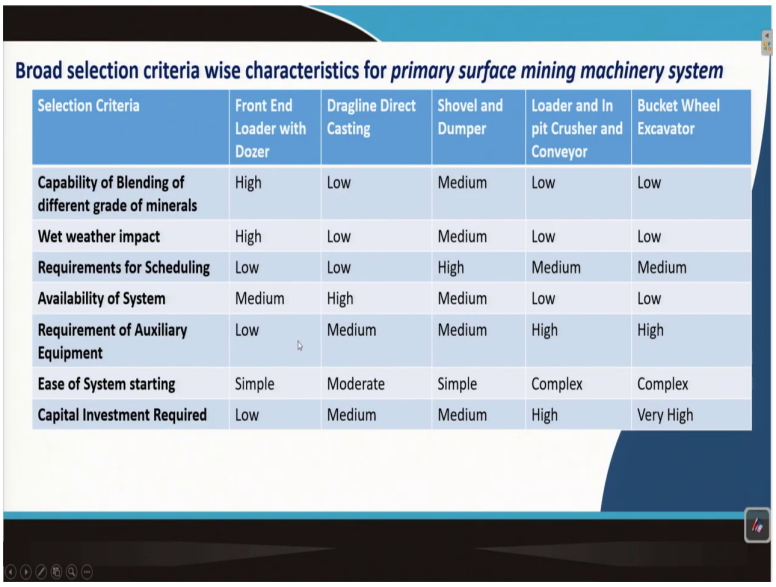

So, depending on the criteria, you can select the machines. Say for example, if the capability of blending of different grade of minerals; that means if that grade has got a white, that is the deposit has got a variable grain.

Then if you use front end loader, that will be giving you a very good capacity to blend; you can mine at a wherever it is required and then mix them to give the good quality. But if you are using bucket wheel excavator, you cannot mix different; that is selective for selective mining cannot be done by bucket wheel excavator.

Then in a wet weather impact, that is your front end loader and all they cannot work in a very slushy and rainy seasons, they do not work well. Similarly, there systems availability, because the as you go bucket wheel excavator and continuous system, there is a the, it is a complex system, so the availability become low. Similarly, that is the system when there are more

number of component and machines are there to start the system, it takes a complex, you will have to do.

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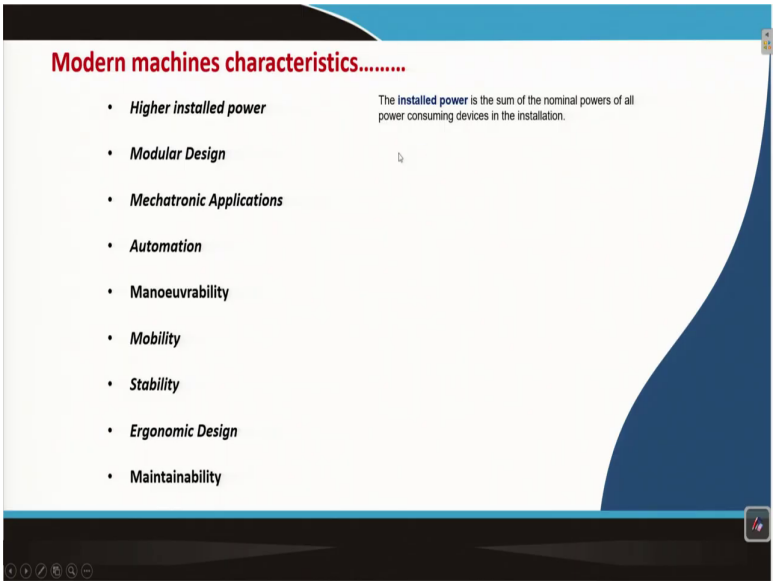

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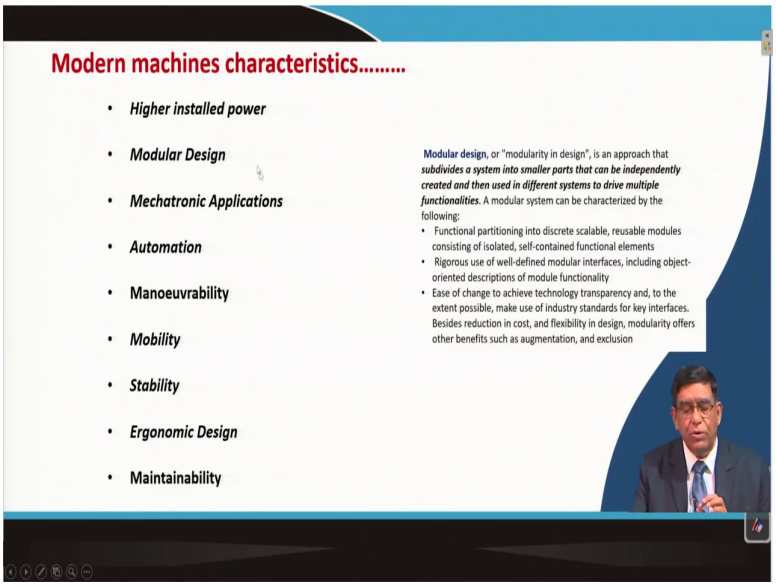

These type of systems are there. So, the modern machines characteristics is your high install power. Your modular design, that is a machine is of coming in a separate group of units and those groups of machines are joined together to give it. And it is if anything goes wrong, you take out that module and then another module, so that is the way it is can be done.

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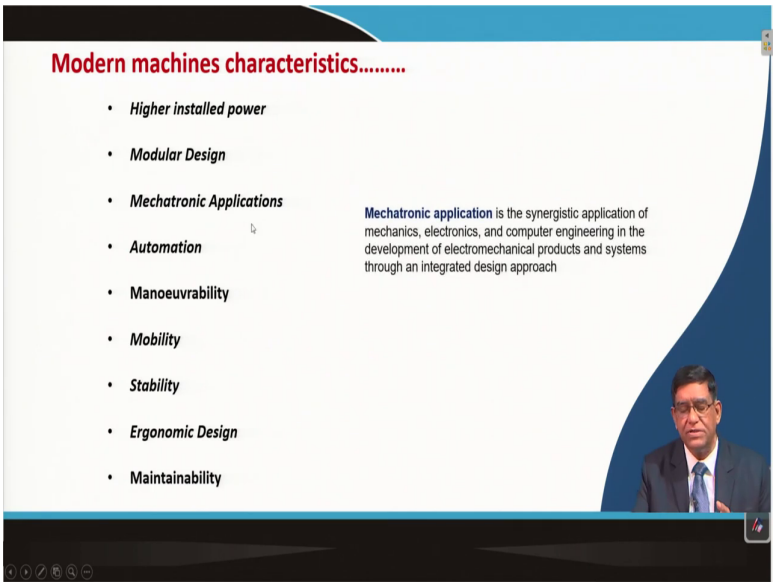

And then mechatronic applications, that is a new machines are coming with a good sensors and with that the whole control can be done.

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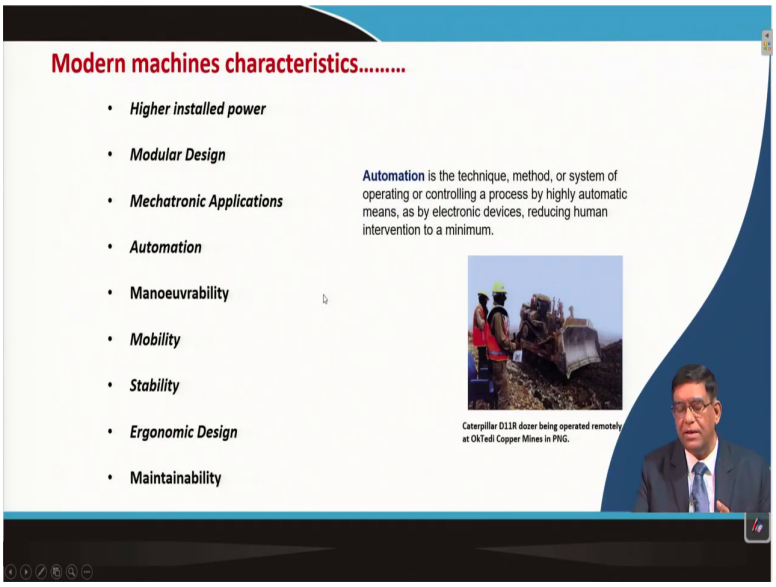

And there is a automations, that is many of that operation can be done without the operator there nearby. So, that is just like you can see here, a dozer is being operated remotely; that is a man less dozer, they are operating like that. Nowadays you are having a automated truck, without a driver the trucks are moving; you can see (Refer Time: 30:05) has produce big.

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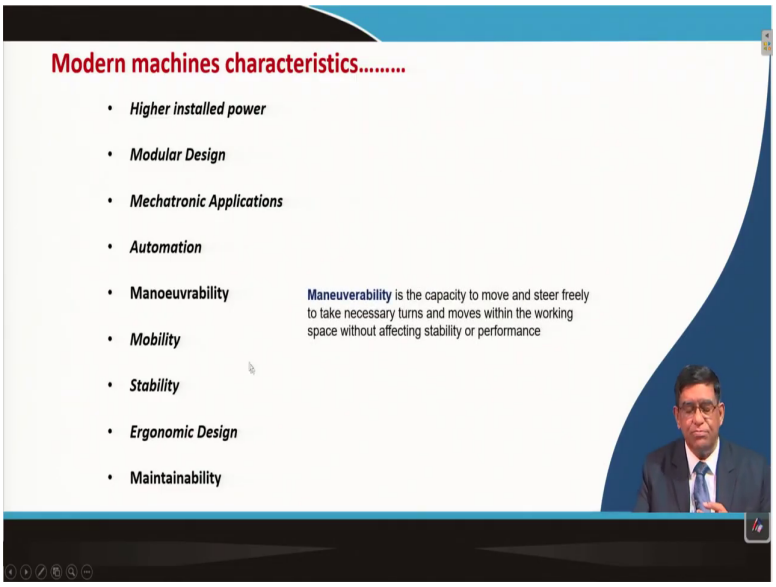

This machine must be manoeuvrable in that particular short area, where there is a difficulty.

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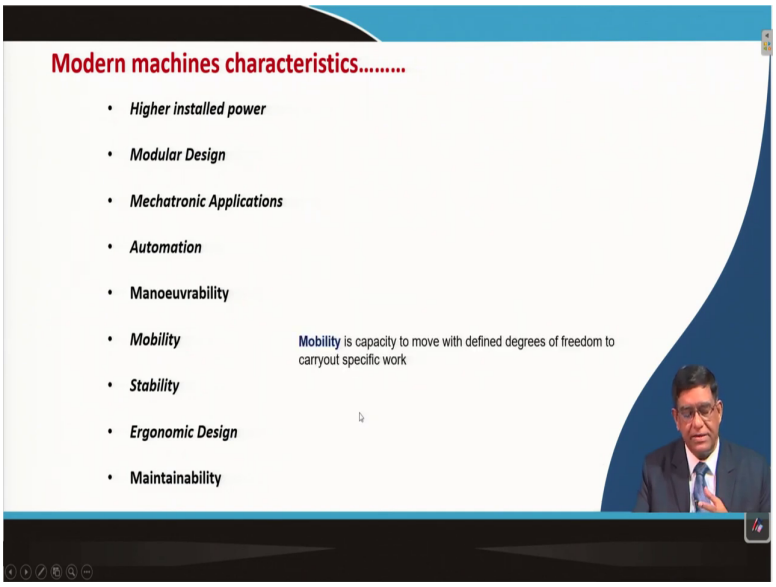

Similarly, the mobility of the machines; that is capacity to within a define degree of freedom, it is the mobility

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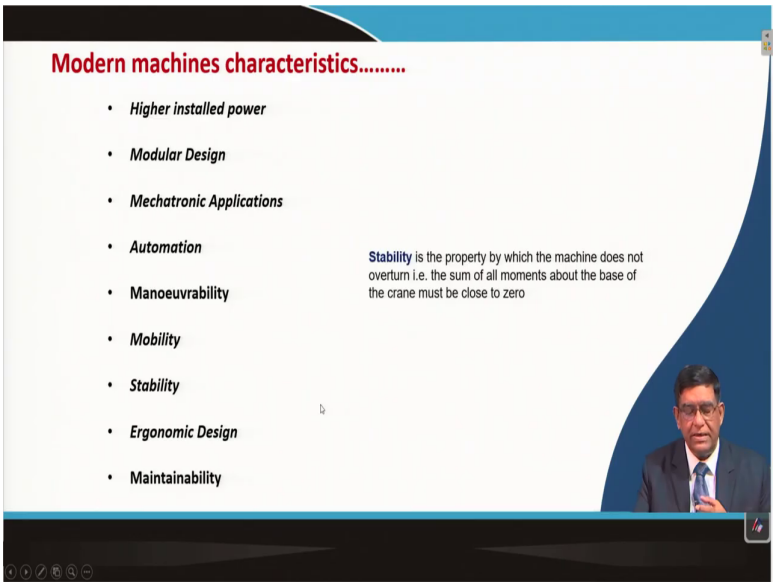

It will have to be stable; it should not get overturn, so that the machine will have to be stable; because it will have to working in a unrelated area.

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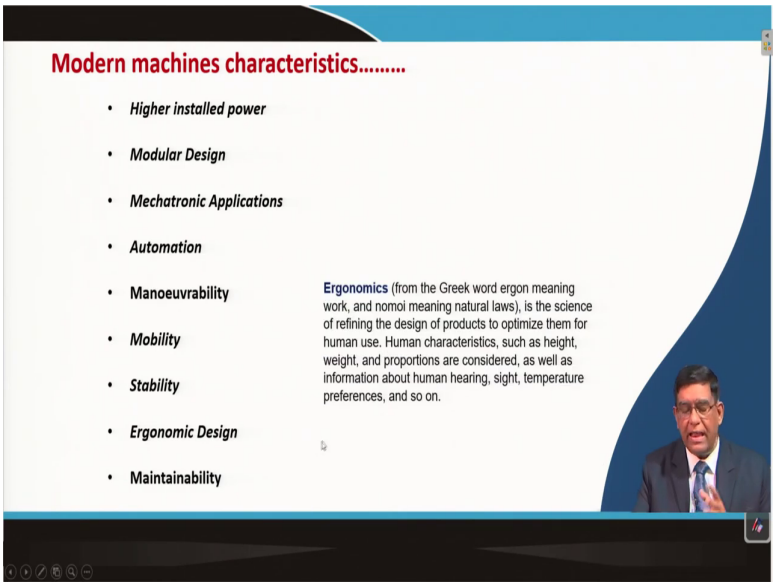

It should be ergonomically, that is comfort to the operators; the design should be ergonomically designed and the machine must be maintainable.

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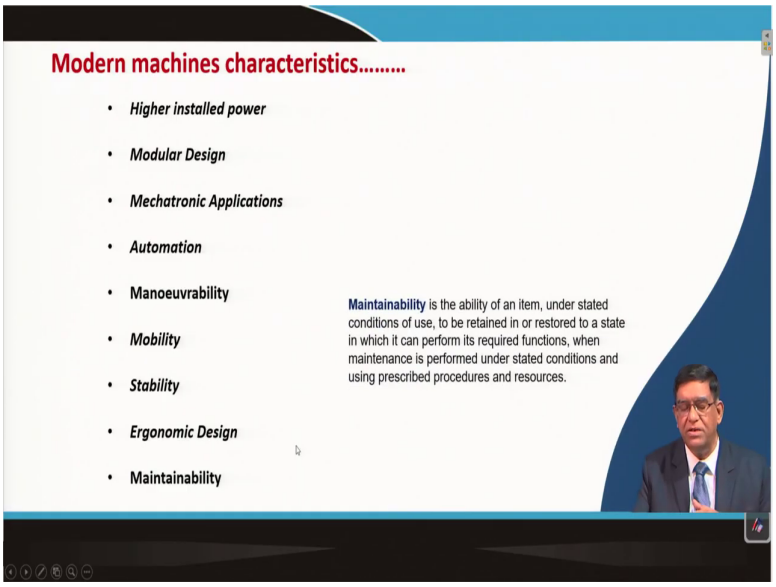

That means, if it is anything goes wrong, it should be brought back to the normal operating conditions within a very less time.

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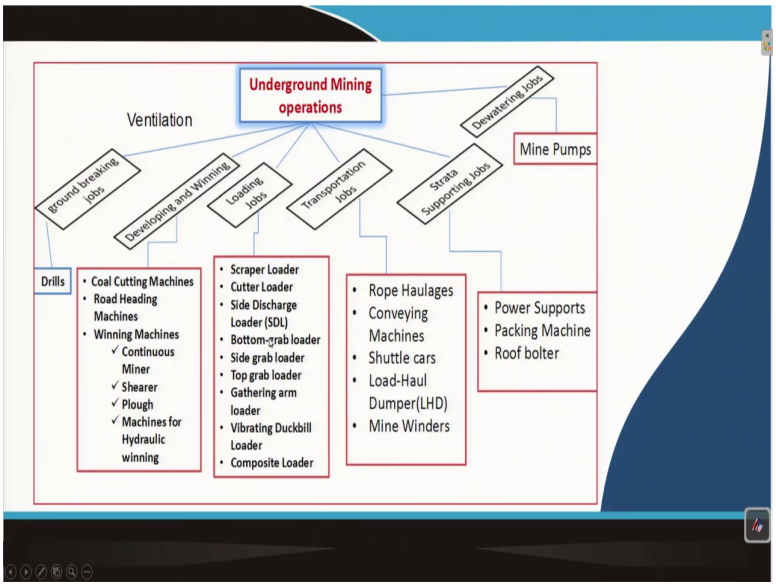

So, this is the thing which you can do with the machines. Similarly, underground mining machineries are also having for different operations like ground breaking job, developing and winning job, loading job, transportation job, strata supporting job, dewatering job and for that different wide range of machineries are there. We will be discussing about the underground mining machinery in our next class, that I will introduce them in detail.

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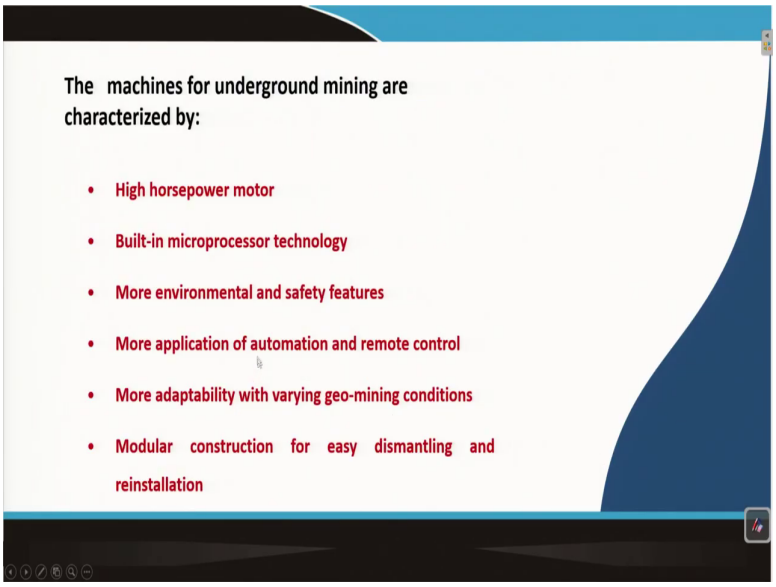

And the machines for underground mining machineries, they will have to have high horsepower and (Refer Time: 31:16) have to work in a very robust manner, in very different way. Again I will be telling you this underground mining machinery; how they are working, what are their characteristics in our next class introducing to the underground mining machinery.

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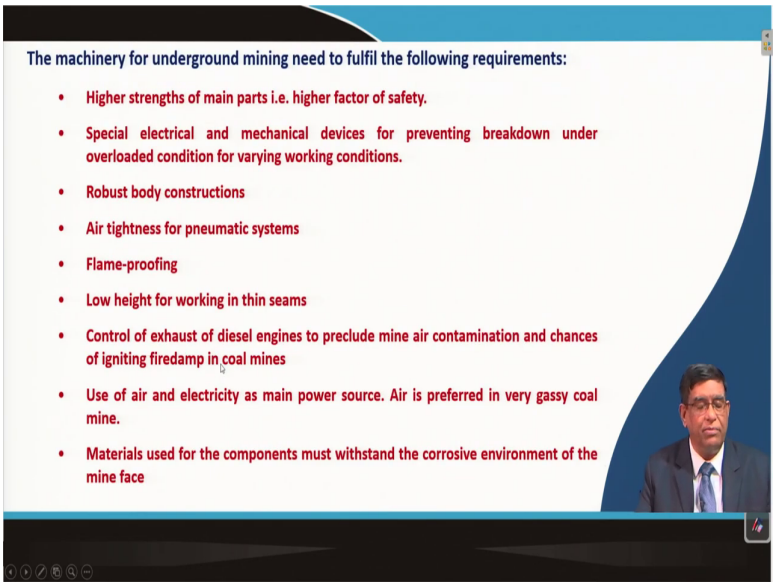

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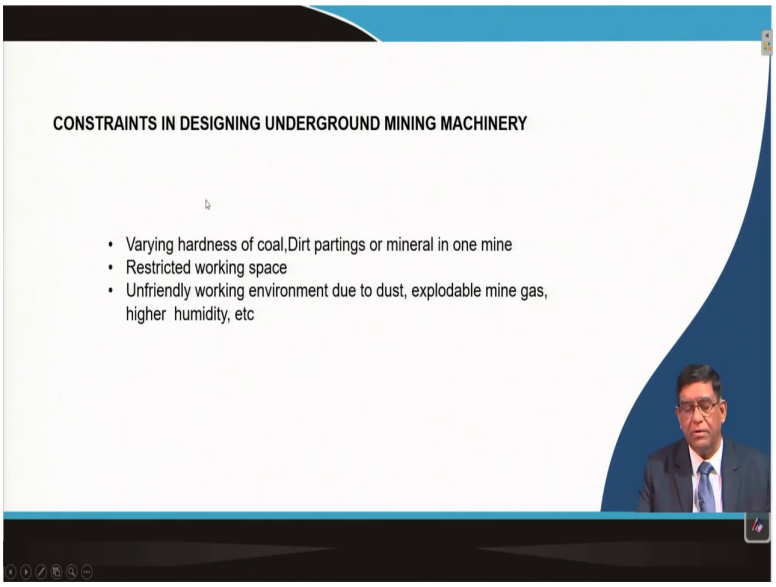

So, they will have to fulfil number of conditions and these are some of the constraints in our designing underground mining machinery are there and those to designs constraints will have to be taken care of while studying the mining machinery.

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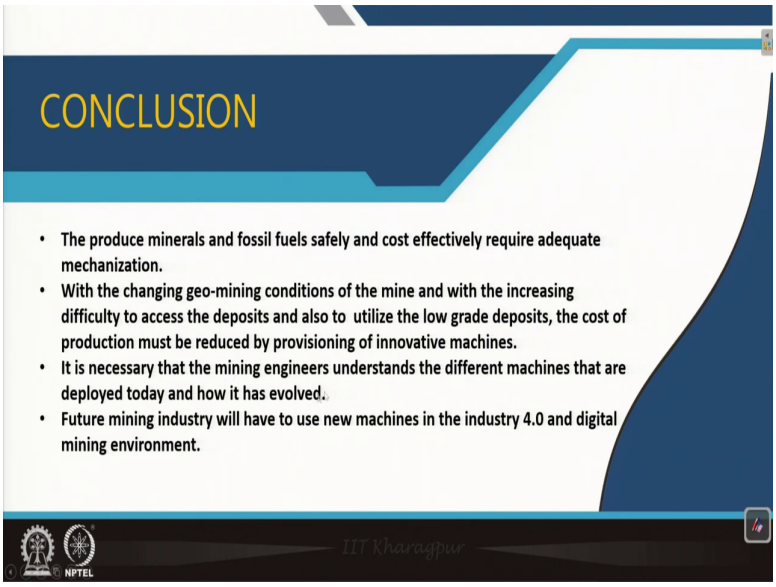

So, to produce the minerals and fossil fuels safety and cost effectively require adequate mechanization. And, with the changing geo mining conditions of the mine and with the increasing difficulty to access the deposits and also to utilize the low grade deposits, the cost of production must be reduced by provisioning of innovative machines.

So, there is a huge scope of innovations and new work in the field of machinery, whether in a changing certain components, whether it is adding some operational features. So, your it is necessary that the mining engineers understands the different machines that are deployed today and how it has evolved; their trend of development need to be known by the mining engineers, so that the future mining industry will have to use new machines in the industry 4.0 and digital mining environment.

Now, that how IOT is going to change this things, how your data analytics can help; that is how the different machine parameters, parameters influencing the performance of the machines are monitored and then what type of sensors will be put over there and so that the overall control can be improved.

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So, you can study this books, there is a Mining Machinery and Capacity Utilization a book is there by produced this was published by Signash. There is also a book called a Heavy Earth Moving Machinery, this books published by lovely Prakashan Dhanbad; Professor Amitosh Dey give that all the surface mining machinery. And there are some other books like a Moving the Earth of Nichols that book also will be very useful.

But today, you can get a lot of information's about this mining machinery in the internet and there are open book libraries. I will be telling about those sources, while discussing the individual machinery and individual things.

Thank you very much.