Mining Machinery
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Module - 05
Lecture - 22
Surface Mining Machinery
Machinery for Continuous Excavation: Bucket Wheel Excavators

Welcome back to our discussions on Mining Machinery. In today's class we will be discussing about the machines which are used in continuous mining operations. So, far you have studied about the cyclic mining operations where the machines like shovel, dragline the these machines are working, but now this continuous mining machinery where the cutting operations and transportation operations both are continuous.

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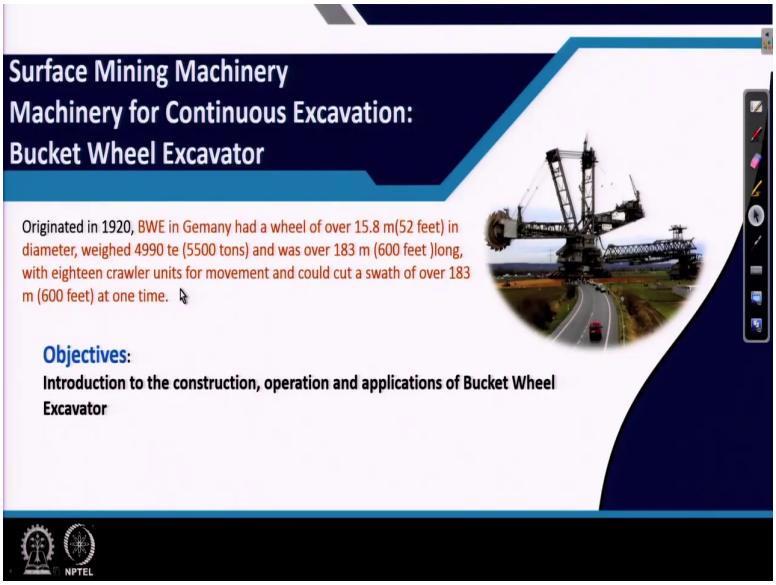

So, in this category we will be discussing first one machine which is a bucket wheel excavator, this machine was originated in Germany in 1920s and later on because of its high production capacity a lot of interests were there and the main development came's in the mid of the last century when very gigantic big machines started coming up.

As you can see in this figure a bucket wheel excavator where the main component is a wheel on a receiving boom and a which has gone to a tremendous size that you can see the dimensions, where your all cars and everything looks very small compared to this machine.

This machine is having a wheel of 15.8 meter diameter you can imagine such a gigantic machine where inside the bucket a big dozer can give totally put in, that means, two small Maruti car can enter into one bucket such type of big buckets are there in a bucket wheel excavator. And it has got the overall about more than 180 meter with part it will take as a as it work and which is mounted on 24 number of crawlers.

So, that is why this is a big machine used in continuous mining operations we will be discussing today about this machine what that, how it is constructed, how it is operated. And you should be interested to know about this machine as it is being used in India in Neyveli Lignite Corporation from the 1950s, it is operating over there and Indian miners they have example of this machine in a very hard rock.

Normally these machines can be very easily working with a rock of less than 20 mega Pascal uniaxial compressive strength, but in India it is more than 50 mega Pascal's rock as well as sometimes even harder than that particularly in the Codell Sandstone it has been used along with some a special type of blasting operations. So, this machine is also used in some of the lignite mining in Rajasthan and Gujarat.

So, this is not manufactured in India by indigenous company, but yes there are that erection units and then the by bringing the components assembling has been done in India for number of things latest one was done by TAKRAF. So, I think these machines is worth studying as because it is a there is a lot of mechanical engineering, electrical engineering, control

engineering as well as the metallurgical engineering for selecting the materials for different components.

This is a machine which itself can be a subject of study and research.

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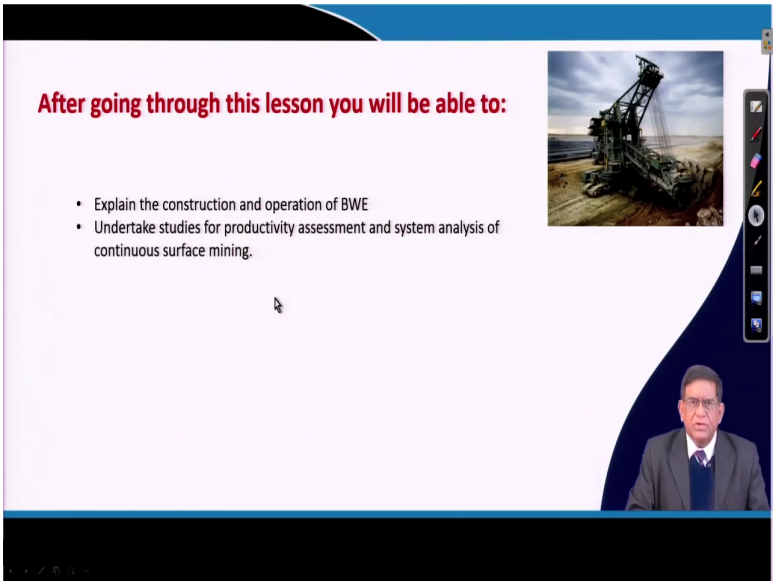

So, today we will be discussing about this machine. So, that at least after going through this lecture you should be able to explain that construction and operation of this machine and you should be able to undertake studies for the productivity assessment or the system analysis in which these machines will be used.

And so, that if you want to design a mine with this equipment you should be comfortable to start the work and go ahead with your learning system because the class will be introducing

the subject, but you will be a learner for this subject may be for quite some time if you have got interest.

So, the figure you can see that how this machine is used, this machine is used always in a very large open cast mines because you can easily understand such a huge machines will be of very high cost. So, now, such a costly equipment it should have a very long life and that is why a deposit where it is a very large deposit there it is used; basically it is used in lignite and coal mining where we have got a life more than 30, 50 years of age and that it should have a.

So, that the large capacity may be 10 to 20 million ton can be easily produced depending on the type of deposit. But it must be a flat deposit that means; the inclination of the seam should not be more than say one in 21 in 30. If it is a more than that then it will be very difficult, it is very good for flat seams.

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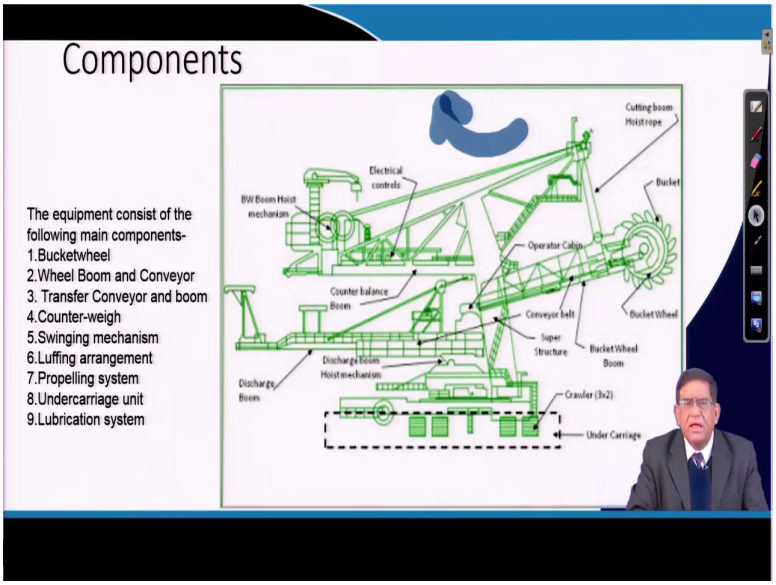

So, as a construction wise this schematic diagram gives you an idea of what is this machine made of. You can see here this is the wheel bucket wheel and where the buckets are mounted on its. So, that there is a inner ring and then this material which is excavated from this bucket which will be engaging maybe this at a bucket at the bottom will be engaging with the face.

And a depending on the slope angle a particular bucket may be this or this will be in contact with, then rest of the things will not be in contact with the face. So, now, this will be rotating in these directions and then the material will be transferred via a rotary plate or chute to a conveyor belt which is mounted on this receiving boom. So, that means, this machine comprises of a undercarriage and a super structure.

Undercarriage part from say this part here which is mounted on some three sets of crawlers, out of which one set is comprising of two crawlers. So, the two are your idling crawler and the one set is a steering crawler. So, this under carriage is having this structure pylon structures where one is this receiving boom and the other one is your discharge boom and another boom which is called your cantilever boom.

So, that the force and the weight which will be there coming with the material on this bucket will be counterweighted with this discharge boom. So, basically structurally this undercarriage and superstructures. Superstructure is having this cutting boom or receiving boom or sometime it is called bucket wheel boom.

And this is your discharge boom which are exactly a lattice structure, which is that supported on a point pin joint here and it is it can make a up that is your lowering and hoisting operation which is done by a rope winch system.

So, here is a rope drum and these ropes it is connected to this wheel so that this boom can be in a vertical plan move up and down with the help of this rope winch. And then this height this is a discharge boom, it can also be raised and lowered by a hydraulic system.

You can see over here at this point there is a hoist that is a hoisting and lowering mechanism for the discharge boom.

So, that the material which is transferred by the bucket to the conveyor belt mounted on this boom is through a that is your a discharge the suit that is a it will be delivered to the conveyor belt in the discharges boom from where this material will be lowered to the next transporting mechanism which is a it will be loading into the next set of conveyor belts.

So, here this superstructure is a slewable, that means, it can rotate; it can rotate around its axis it can rotate about its axis and then it can also it can this discharge boom; discharge boom can discharge boom can also be slewed or it can also rotate about its this axis of this, but separately. So, that means, when this bucket wheel with bucket wheel boom and the superstructures it is rotating it can rotate 360 degree independent of the discharge boom.

Discharge boom can also rotate 360 degree irrespective of this. So, this arrangement is there, but while in operations normally the discharge boom will be rotated some angle, so that the angle between this receiving boom and discharge boom they do not come very closer.

So, that is why there will be a limit switch, if it were discharging if you are slewing the discharge boom with a particular position of the receiving boom, it can depending on the size and dimensions and you can set it can be 20 degree 30 degree 35 degree depending on that.

So, now you understand that is the construction of this machine is basically a undercarriage superstructure this cutting boom your discharge boom counterweight boom. The counterweight boom it houses all the electric cabinets all these your then the hoist winch. So, that the control mechanism your centralized lubrication system all are housed over here and they give the sufficient weight. So, that this machine imbalance.

Now, this super structure is just placed on the undercarriage and there is a some your that locking system here and that is why while traveling you should not travel the machine in a

very big gradient otherwise what may happen? The superstructures may come out and it can just topple down. So, these are the basic construction and operation of this machine.

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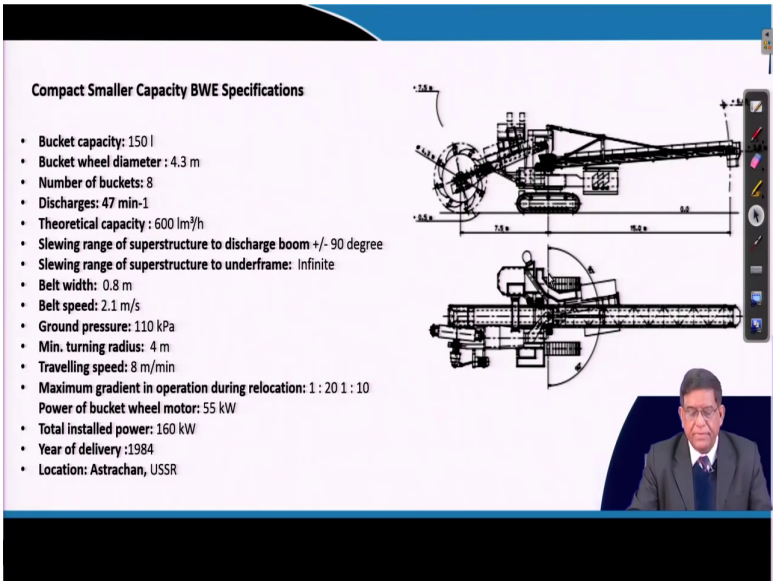

So, now, coming to the next you can see here. This machine it was different designs were available that is your you have some of the machines were very smaller and where they were called compact bucket wheel excavator. And this compact bucket wheel excavator as you can see here the bucket wheel diameter is only 4.3 meter.

I told you that the bigger one was 15.8 meter and this is a very small and a compact bucket wheel excavator. Here the you can see this that bucket wheel diameter is 4.3 meter and number of buckets is 8 in a large machines the number of buckets can be up to 10 and sometimes even more. And then depending on the hardness of the rock between two buckets there could be a pre cutter.

So, those are different advancements are there, but why I am showing you here this figure, you see the orientation that in this figure you are seeing the bucket wheel which is it is not exactly kept as a that perpendicular you can see it is slightly inclined. So, that when the material is discharged it can be easily guided through a suit to the conveyor belt this part is the this is the your cutting boom or receiver boom you can see the receiving boom or bucket wheel boom in a projections it is shown over here.

So, this is at a; this is at this angle it can be raised and lowered you can see that this is the height of up to which it can be raised and the bench height can be cut over here. And then the material is transferred by a transfer hopper here it gives to a hopper and from there below that this is the hopper portion you can see.

And then below that hopper is this discharge boom the discharge boom where it is carrying the material by a conveyor belt and then from here it loads there could be another conveyor belt below these things. Is it clear? Now, you can see the operational range, that means, these machines its travelling speed is 8 meter per minute, but if it is a heavier machines it will be much less than this depending that is your travelling speed is also related to the weight of the machine.

The overall, but the pressure such a huge machine, but giving only 110 kilo Pascal ground bearing pressure because the crawlers they are wide tracks that is why they give less. Now, here it is a very small machines the supporting system is just like a two point supports like your dozer four point supports like dozer, but in the larger machine there will be more number of crawlers to reduce the bearing pressure to, so that the machine does not sink.

Then you can see here the slewing range that means, the super structure discharge boom can do here only 90 degree so, that in one positions it can do a loading at a 90 degree. So, this is in the other case slewing speed of the under frame it is giving infinite means it can 360 degree it will be rotating over here.

Now, this machine is operated by electric power, the main power consuming motor that is the this bucket wheel drive motor which has got here it is a 55 kilo Watt in a small machine, in large machines it can go 750 kilo Watt such a huge powerful machines are also there.

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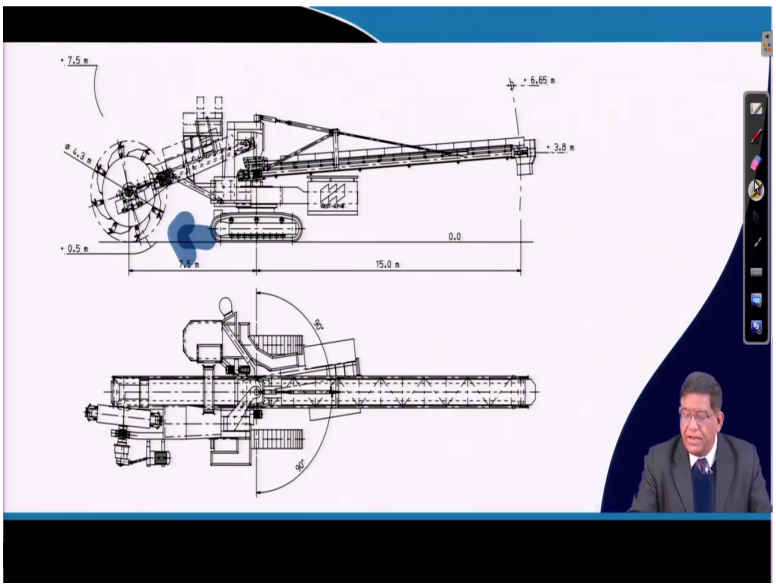

You can see that this diagram gives you a little bit clearer picture that whatever was shown in the previous diagram. You can see this clearly there is a hopper that is the material is cut by this bucket and then after this much bucket cuts the material and then discharges to this conveyor belt and from this conveyor belt material coming over here and then it is going and it is given over here.

So, the basic constructions of the machines you have now understood there is a operator cabin which will be controlling. Now, to cut this machine this machine does not give a crowding force like your shovel you have got a that you can give a push by crowding here, this

crowding or taking the rock cutting is given by moving this that your conveyor belt, sorry moving this machine forward in this directions when it will move.

Then your the bucket teeth will be giving a bite. So, that is the way how it is exactly operating. So, that means, this machine does not have a crowding force, the machine crawler travels forward and by that the teeth give a push. So, that is why while you are working at that time you should not travel much because if you give a big push then a the bucket will not be able to rotate because of the if you give a big bite.

Then the cutting resistance will go high and that resistance cannot be overcome by the motor then the motor will be in trouble. So, that this type of situation does not take place there are number of limit switches and control switches. So, that you can set it, that means, while you are in a excavation mode that that your crawler you can set it say it will give a 2 inches move or 3 inches move or for 4 inches move by that only you can control giving that way.

So, there are number of issues like that you will be knowing about these machines, how it operates.

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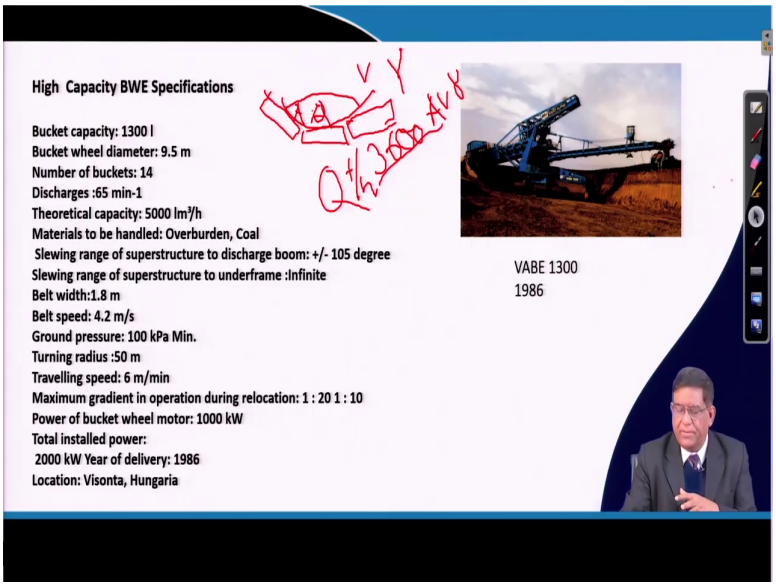

Now, if you see here a larger machine that is your 1300 liter capacity compared to the previous one where it was 150 liter capacity of the bucket and here it is a machine which has got 1300 liter capacity. Now, to give a 1300 liter the bucket wheel diameter is 9.5 meter and number of buckets you can see 14 meter.

Now, this exactly the wheel at what speed it will rotate that will be depending on what is the cutting resistance of the rock. Now, depending on that speed you can find out that exactly how many number of buckets will be discharging per minute and that will determine what is the productivity of the machine.

So, that means, if a 9.5 meter diameter bucket is having 14 buckets attached to it. And if it is to give say you want a production say it should give 56 number of buckets per minute should be loading onto the conveyor belt. Then you can find out at what speed it will be moving, but

this how much material it will be discharging on the conveyor belt will be determined by what is the capacity of that conveyor belt.

Now, the width of this conveyor belt it also varies in such a machine like 1300 liter bucket capacities we have to have the belt width will be minimum about 1.8 meter. If you are having a 1.8 meter belt which a troughing angle say 40 degree trough belt conveyor you can find out what will be the carrying capacity of that bucket. Now, if you know, that means, if your carrying capacity of the bucket is known say.

For example, if you are having a conveyor belt where your this is exactly we are having a idlers over here on this idler your the this your conveyor belt is being placed and the material which is loaded over here that will be certain area this area of material is carried.

Now, if the if this is your area is a then if this belt is moving at a velocity V and if the material density is a gamma, then your in a meters per second velocity, that means, 3600 your A V and gamma this much ton per hour if it is gamma is in ton per meter cube velocity in meter per second. That means, this much material will be discharged by the conveyor belt.

Now, if you know this much quantity of material is being it is a capacity of the conveyor belt, then you can find out that what should be the rotary speed of this bucket wheel. Because with that you can find out that this whenever you will be running working with this machine the bucket discharge need to be calculated.

So, this is the way how you will be exactly determining, what is the production capacity of this machine. So, now, you can find out that such type of machine used in India they are even bigger than these machines. So, we are having very big machines at Neyveli Lignite Corporations.

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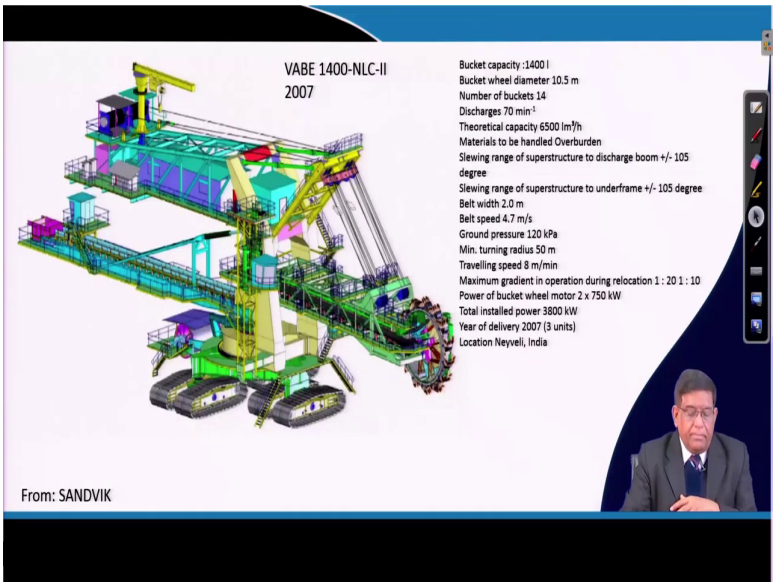

Where our this is a machine which was only in 2007 it was given by SANDVIK to this Neyveli Lignite Corporation. These machines is of 1400 liter capacity and it is also having a bucket wheel diameter 10.5 meter your number of buckets 14 and number of discharge that is 70 buckets can be discharged per minute.

So, you can easily find out if 70 buckets are having 1400 liter capacity what will be the maximum theoretical capacity it can deliver per hour can be calculated. Then if you know that quantity then you can find out what should be the belt width over here this belt is a 2 meter wide belt are there in this 2000 millimeter belt on this conveyor belt.

So, you can this figure I think gives you an idea that is bucket wheel is there now that supported on 6 crawlers that is two sets of crawler this one and one back of back side of it these are this those this is a idler it is the step follow. These two sets are your steering crawler

below this that undercarriage there is a hydraulic system by which you can exactly steer this machine these two sets of crawler and this will be following and you can rotate these machines.

Now, the belt speed is at a 4.7 meter per second you can now again calculate it out that if the belt width is 2 meter and then if it is at an angle of say 40 degree and then it is moving at a 4.7 meter per second and if the what type of material. That means, how much will be the cross sectional area of the material on the conveyor belt to give a particular capacity.

So, those type of calculations are done and then that is also done for designing the machine. You first determine say for example, with these machines we want to produce 12000 ton per hour or in other way we can say a mine we want to produce 10 million ton per year.

Now, then you can find out what will be the production hour per hour, that means, that whole year total how many effective hours are there divided that 10 million ton you can find out per shift how much is required and then you can find out say we get 12000 ton per hour then only we can reach that quantity.

So, that for taking 12000 ton per hour, what should be the belt this wheel speed, what should be the belt speed all these things are can be calculated in your normally these are done in the tutorial classes when you will be there working on these machines.

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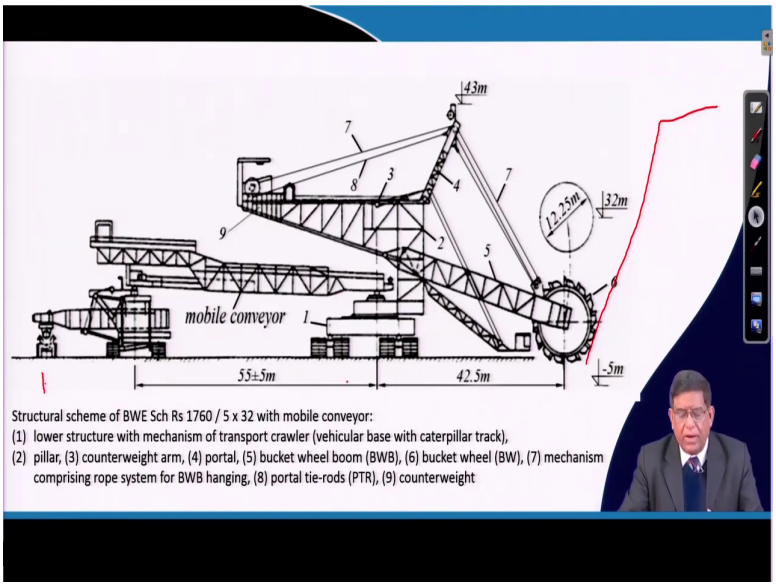

So, now coming to this let us see here how these machines exactly the important point of this component wise, this schematic diagram you should be noting here that discharge boom. This discharge boom because of the to increase the distance between, this is a crawler that this is exactly a conveyor belt which is mounted on the pit floor, where the material is carried and here is your the you can see here that is your face.

That means, the mining phase is here suppose this is your slope you are excavating with this machine. And here this is your conveyor belt locations, that means, your from here to here this distance should be that will be giving exactly the total production capacity and after this you will have to shift this conveyor belt nearer.

And the machine will have to work in your mine phase design we discuss about that, but to increase this the discharge boom is also having a crawler here and it has got. That means, the

material from the bucket wheel excavator is coming to the there is a discharge boom and from there it is again transferred through a hopper to a another discharge boom which is running onto this conveyor belt.

So, you can see here the parts shown this is the lower structure for the transport crawler we say it is an undercarriage part you can see the pillar or it is also called the pylon structure of the super structure and then this is your 3 is your counterweight arm and then you have got this portal.

That means we are having with a counterweight boom a part on which exactly to operate the rope winch which is here for the bucket wheel boom is this one and there we have got that bucket wheel and then this bucket wheel is hoisted and lowered by this rope winch mechanism.

And then there are some tie rods by which exactly you are connecting this a. So, that this material structural rigidity which is required is given and the support is given. So, this structure these are all lattice structure so that with a minimum weight it can give the required strengths.

Moreover such a huge tall machine sometime it is height is more than your 40 meters such a high and such a weight, if it is working in a wind area the wind load it will have to be minimum. So, that is why if your lattice structures it is gives a minimum resistance to the wind energy. So, that is why the machines can remain stable under high wind conditions. So, these are the things which are taken while designing this machine

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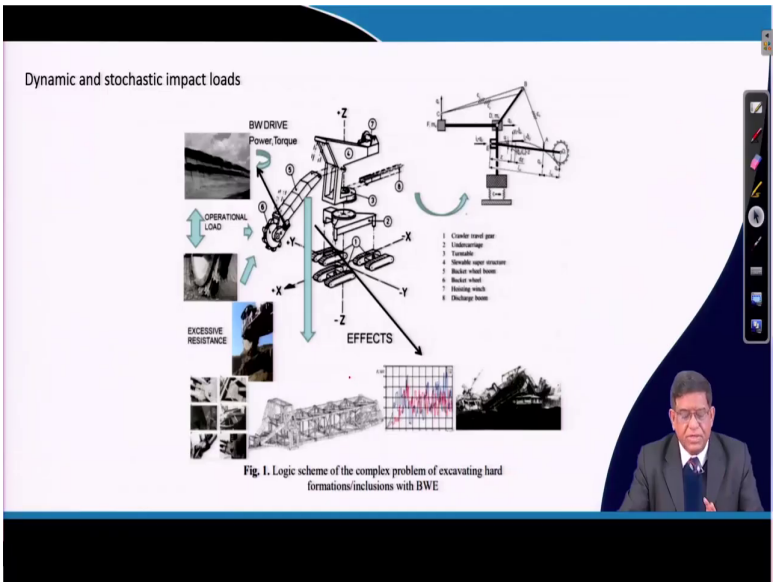

So, once again to know the constructional components you can see here how these are the crawlers on which, that means, we have got the three point support; three point support of the machines and we are having the superstructure, this is the pillar or pylon structures.

This is the TIA portal this is your receiving boom this is your discharge that is your discharge boom this is working as a counterweight boom again schematically you can. So, the bucket wheel excavator this type of diagram you will have to try for drawing it.

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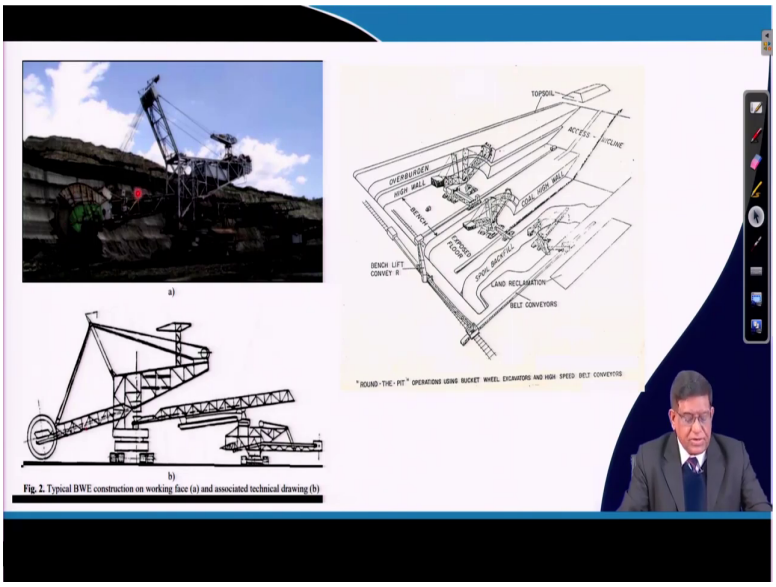

So, coming to the coming to these machines operations. Basically the components how they are working we have shown about this machine in a field how it is applied. You can see here it is removing the over burden this machine is lying over here and this is a conveyor belt which is called a shiftable conveyor belt and this is giving the material transferred to the other conveyor belt.

So, that means, the bucket wheel excavator touch the face give the material to a series of conveyor belt to take the material down to the dumping yard. So, this is your the back filling or the dump is overburden is being dumped over here. So, it is coming from the bucket wheel excavator via this conveyor this conveyor this conveyor this conveyor and then it is coming over here.

So, the in a surface mine this is a schematic layout how this machine is being used in the real diagram you can see here how it cuts.

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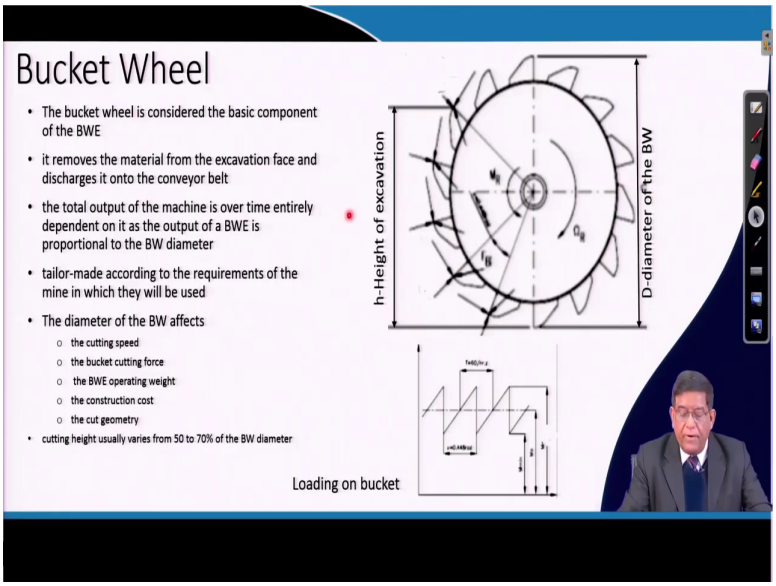

So, now the main component of this machine is this wheel. Now, you can see here on a face that is as you have seen here in the face the bucket will be engaging only a part of it. So, that is why the whole bench may be cutting in some terraces that is whatever at one go it can take engage this much.

So, this bucket to this bucket can be engaged and that whichever it can engage that will be working as a terrace in your surface mining, how the phase advances there we have said that terrace cut and drop cut you might have studied in your working method. Now, this is the engaging buckets and that different forces will be coming over there.

So, the bucket will be getting a load because it will be for some time it is under in constant touch and then it is released. So, that means, the force on it goes on increasing, then after that it is not there. So, that means, that it will be coming the bucket will be loaded that is cutting resistance will be there for some time and then it will be 0. So, that is why you get a the load diagram on the bucket is a zigzag manner

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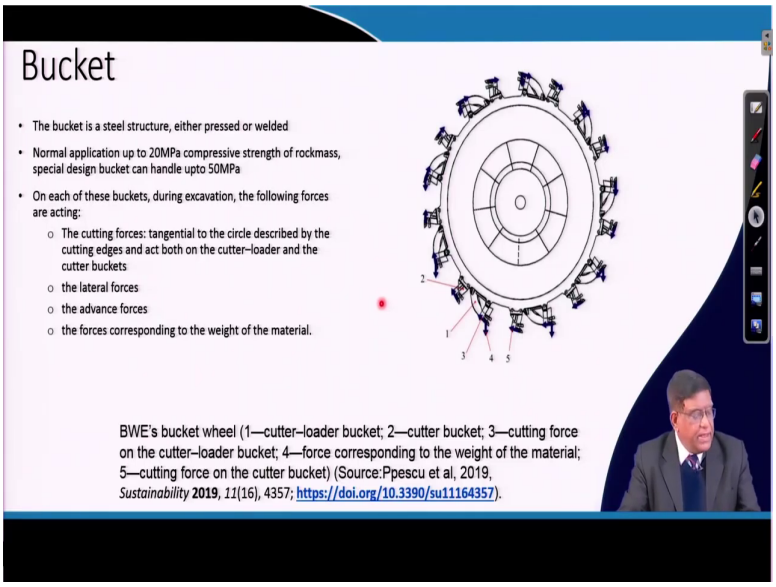

If you see here this sometimes when you have to use on a hard rock, then your there is a between two buckets there is a cutter; that means, it will loosen and cut the material and it will not exactly load onto the bucket.

So, this bucket is cutting in this you are showing in this direction. Now, here the how different forces acting on it the cutting resistance that is the that how much resistance the rock

is giving and then when the material goes inside that will be exactly giving as a load onto the bucket.

So; that means, a cutting force which will be getting over there because of the its rotations given over here and that load it will be coming on to the material till it discharges. So, the material load will be discharged and then say from here when it is rotating like this cutting over there and the material is discharged here and then there is no load coming on that again it will be like that.

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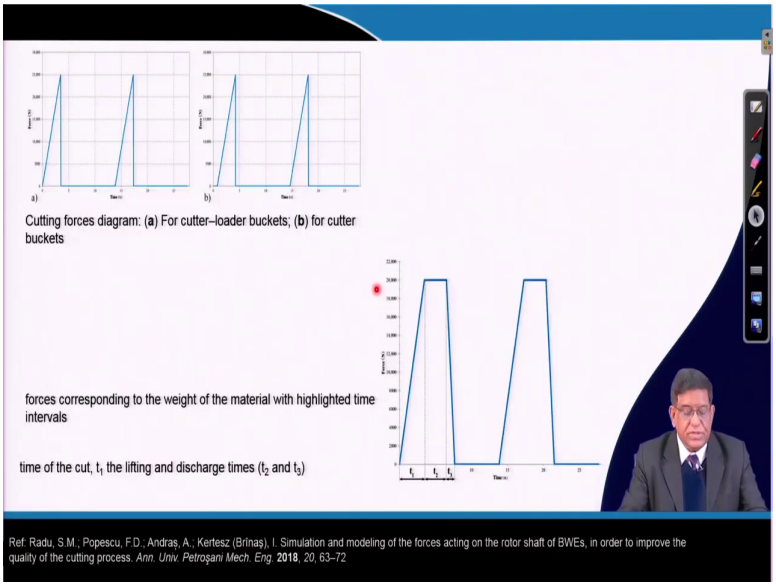

So, that is how exactly you analyze the cutting forces and. So, cutting force will be there for some time and then it will not be there. So, it will be repeatedly loaded the bucket will be repeatedly loaded and the materials also will be repeatedly giving the load. So, there is a

different way the bucket will be loaded, so that means, while analyzing the different forces and the energy required you will have to study in this way.

So, while you if you want to do a detailed research on this you can find out that how this exactly forces are coming onto that bucket teeth and the bucket because the damage of the bucket due to operations, it will be based on how much.

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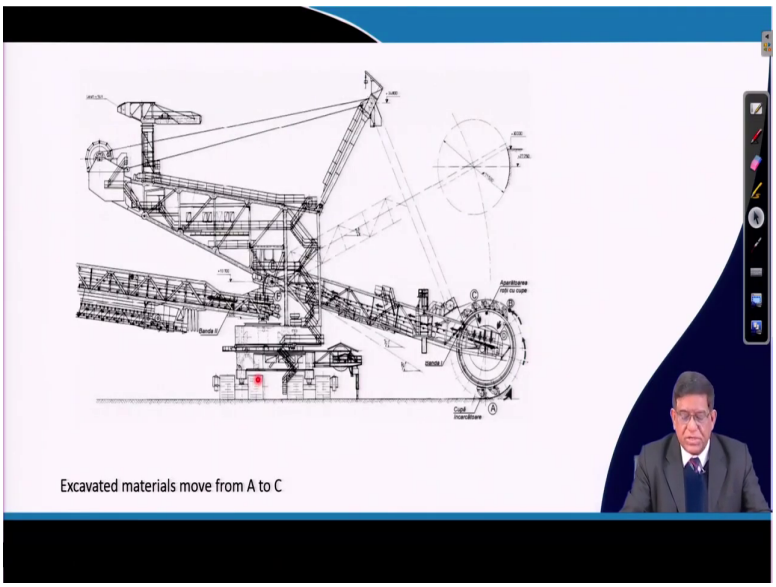

Say for example this bucket is cutting in this directions it is engaging at this point A and then up to the point C that is the material is there in the bucket from C to A at that time it is an empty bucket it is rotating and with a speed it is attacking the again the face and then material is getting collected.

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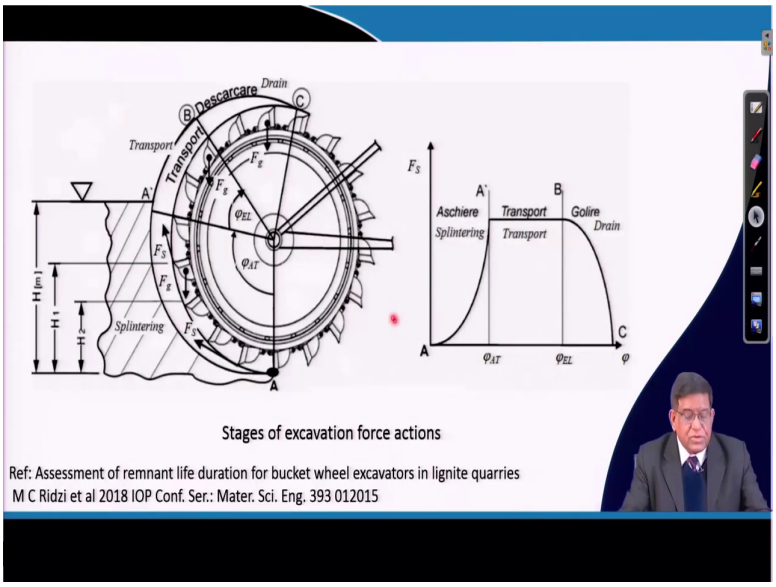

So, now, these operations when it is engaging and then cutting your material it is just splintering the bucket will be getting loaded over here then it does not cut. So, this is your bench height or that that is your the terrace height up to this much only this bucket can cut after that because it will be rotating like this it will be coming out of the face.

And then this is material is transported over here and from this it will start by your centrifugal force this will be started coming out and the material will be discharged. So, that at this point the material will get fully recharged the empty bucket. Now, comes and then it is coming over there with the speed and rotate.

So, that means, the production is coming from basically how it is engaging in this. So, your productivity calculations will have to see how the depending on the dimensions of this bucket this diameter it affects. Because then you can take a bigger or a smaller and then how much

slice of the material it will be going lot of studies have been done over the years. So, this is a very interesting topic where you can study in different cases.

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Now, you can see that depending on the rock conditions the buckets can be different and the teeth on them it will be different. This teeth you are seeing over here it is what in the Neyveli Lignite Corporations they have that is your they have got the bucket teeth at the side as well as at the bottom and this portion is the lip.

Now, these bucket teeth design and their dimensions it was under constant research because the in operation this teeth will get worn out and then you will have to replace that is where your operating time get lost. If your bucket teeth is not capable of withstanding and rapid wear and tear is there.

So, initially when this machine was introduced in India that was within 20 minutes the teeth used to get brought, but then with the Indian research they could make it increase the life tremendously and there is a lot of development done by Indian operations at Neyveli Lignite Corporations. But you can see here sometimes to reduce the weight of the bucket depending on the type of material your that back side it can be only a chain and you can collect the material over here.

And you can see in this diagram it is very clearly showing that a special type of bucket collecting the material. It definitely it shows that it is collecting a very loose material where there is no much cutting resistances and all. And here you can see how this wheel is given drive over here and then how the conveyor belt is there the material is transferred via this suit onto the conveyor belt and the material is working.

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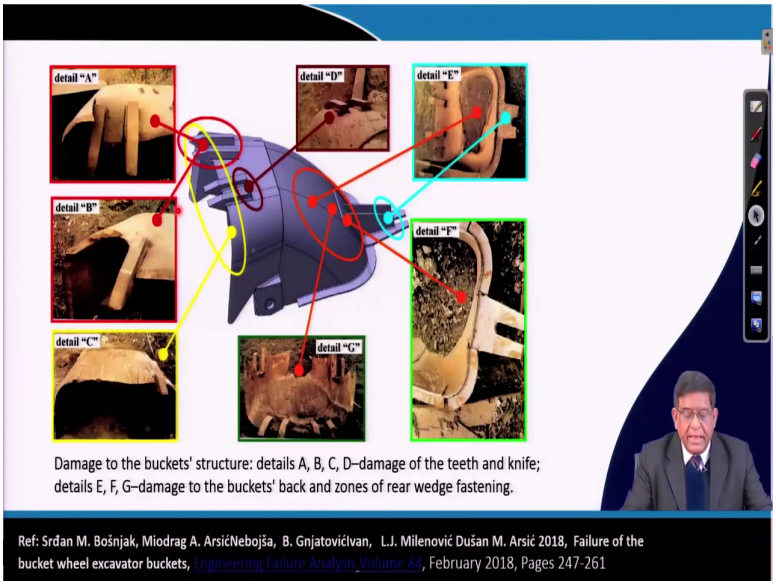

So, this bucket may get damaged by different way and that designing of the bucket and then replacing it. This is also a good business number of our Indian farms are also manufacturing buckets for different type of excavating machines. You can search that who are the main designer and manufacturer here lot of study of the metallurgical study that is how to exactly improve the bucket.

So, that such type of failures do not take place you can see because of the wear and tear the whole bottom it has just got totally worn out. So, that enhancing the life of bucket is a problem which is done by a lot of that, what type of metallurgy, what type of material will have to be used different try different trials have been given.

To increase the life of the teeth of the bucket there are hard facing there are brazing, there are also giving a tungsten carbide tips and then designing the rack angle cutting angle and the clearance angle these three angles of the teeth are to be designed properly.

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Similarly, your the main booms this as I said there are three booms your receiving boom, this is discharge boom, this is the counterweight boom you can see here how the structure is there. So, there sometimes you can study different accidence of machines where you can find out that their wear accidence because of the collapse of the boom because they can collapse where are their weak points at the supporting points and then their load distributions.

How they are monitored that is also interesting why whether they should be your ordinary sections or it could be a tubular those are the detailed design specifications.

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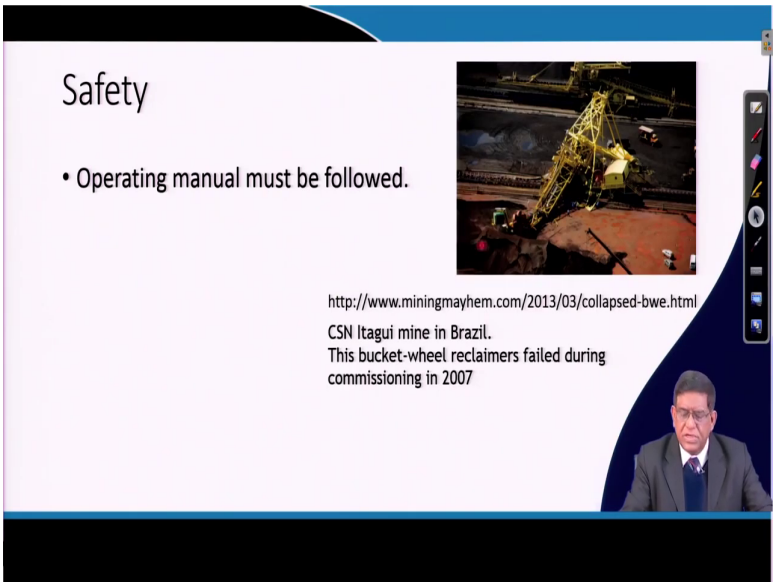

You can see this was a bucket wheel reclaimer which during the erections only it in 2007 it collapsed it happened in Brazil. So, there had been a collapse in Neyveli Lignite Corporation in 1984 a German machines of 1400 liter capacity the discharge boom collapsed and there were an accident taking place.

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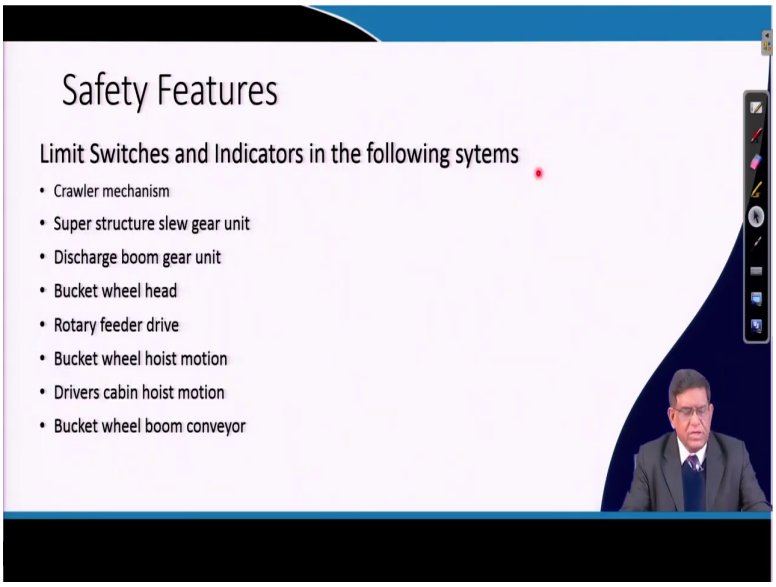

So, to increase the safety of these machines, there are number of limit switches. So, that means, the controlling you will have to study these machines little bit more even in each and every parameter here. That how the crawler mechanism safety is maintained what are the control and what are the different precautionary limit switches are there, that for superstructure slew gear, you need discharge boom gear, you need bucket wheel head your rotary feeder drive.

Bucket rotary feeder means there is a rotary plate from the bucket will be discharging on the rotary plate and the rotary plate will be working as a feeder to the conveyor belt.

And then this bucket wheel hoist motions that is your that rope winch drive cabin noise motion and bucket wheel boom conveyor. There all these machines will be having about

more than about 40 motors and that these motors control each of every one will have to be their control from the operators cabin.

So, this is an area where a lot of development has taken place in the control moreover the lower hosting and lowering of the bucket wheel to the face that will make that face exactly an inclined. So, that means, how much it will be lowered that must be known with this gradient of it lot of control mechanism with a number of limit switches are there.

So, that by to maintain a particular gradient your hoisting operations if you are operator by mistake put the lowering button also it will not go beyond a particular point if you set the gradient at which it will be working. So, this you can study this detailed limit switches depending on that what is your interest lot of literatures are available.

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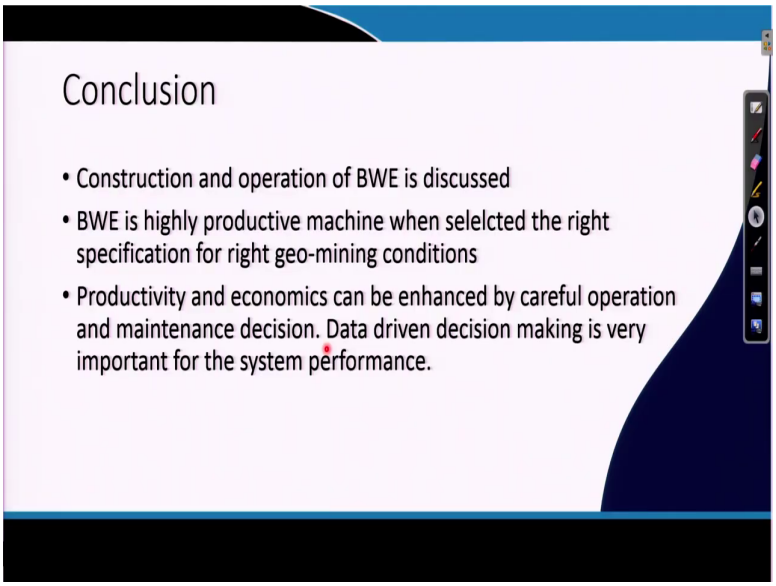

But the construction and operation this is very very well stipulated and that operational manual you must consult to working with. Basically that once you are getting the machines you will be for that at every shift the first when the operator comes he looks into the log book whatever if there were any problem or anything has been reported by the previous one and he starts.

And for starting and operating is very simple, that in the operators cabin it will be mainly by joysticks your main operation is the slewing, traveling, hoisting and lowering of the receiving boom, then your that hoisting and lowering and slewing of the discharge boom and steering the machines. So, these are the main powered functions.

So, the powered functions if it is done properly there will not be there will be a smooth operations, but it requires very elaborate maintenance particularly the lubrications of different things. The whole machine is provided with a centralized lubrication system one for the undercarriage one for the superstructures. So, there is a periodicity of the checking of different gearbox different wires because there are number of gear mechanism by which the power is transmitted.

Say for example, if there are six crawlers, each of the six crawlers will be having six crawler motor and from the crawler motor to give it to the sprocket of the idler. There will be a small transmission system like that in the conveyor belts there is a transmission system from the power to this to the conveyor belt.

Similarly, for the rotary plate or the your feeder plate there is a. So, that your a motor and a gearbox and then the to give it to the final drive to the rotary plate. Similarly, for the bucket wheel and also there is a dribble belt below the receiving boom conveyer belt there is another belt running. So, that if any spillover material is there that will be collected.

So, there are number of power transmission is taking place because of the different your those like that the hoist winch is there is a hydraulic power pack for the hydraulic control of the

discharge boom. So, all this basically whatever you have studied about the prime mover and the transmission they are working over here.

So, the construction and operations will have to take care of that and the main thing is the as a mining engineer your concern is a productivity and economics. And it can be enhanced for that you will have to learn, how you will measure productivity for that is an assignment to you please come forward and then if you have got any doubt you can as I have already given a module page for this all if you are taking a course contact us.

So, that you can do those exercise and calculations and work on these machines. So, as an introductions it is this lectures have told you about the construction and operation and general introduction of this machine, but there are lot to learn on these machines.

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You can go through various references websites are also having material and you can go ahead with it.

Thank you very much.