Mining Machinery
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Module – 05
Lecture – 18
Surface Mining Machinery:
Machinery for Cyclic Excavation: Electric Rope Shovel

Welcome to our journey with Mining Machinery. Now, we have got from the fundamentals of machines we have discussed, we have discussed the site preparation equipment. Those things that for the preparing the site for starting mining what it is done that operations also we have introduced briefly and the machines we have introduced to you.

Now, that while the mining to be done we know that there could be two methods one is surface mining other one is underground mining. And there could be some mining which is a hybrid of this also are there, but mainly in India you would know that more than 95 percent operations of mining is related to surface mining.

And all over the world there is a big trend of surface mining is there which you know because of the advantages and the large production capability of surface mines. But, that large production capacity in surface mining is coming from the machinery which have developed.

So, this the mining is an operation being done by machines which started at the end of the 19th century and the beginning of the 20th century there were a big trend for mechanization of these activities.

And then the surface mining got really boost when the explosives were ANFO, that is ammonium nitrate fluid explosives were found, then they when more amount of rock mass could be exploited to fragment it. Then the necessary count for collecting them and rapidly and transporting them in a huge quantity for utilization.

So, this exactly led to development of new machinery and for that this mining surface mining exactly done by two methods, one is by continuously and another is by cyclic. The difference of the cyclic excavation is when you are doing a cyclic operation it is a same operation number of operations will be repeated and then it is the work is done.

And in some cases it is continuous in a continuous that is exactly the operation is continuously going on going on going on. So, it is not pitting stopping in between or we can see in other way when you take the rock and then by taking it by excavating and then you are giving it to a transporting and then transporting machine is going and the transporting machine is again coming back empty to collect it over there. So, that the machine which was loading each operation is repeated.

There is a cyclic system and in some cases, when the machine is working all the time cutting the material and all the time material is getting ditches to the transporting system and it is just like a it is conveying and taking it out; that means, the excavating and transportations between these two there is no gap so that is what a container. So, these two modes of mode of surface mining you will be knowing as we learn these machines.

Now, for the cyclic one that is which is done the work is done intermittently by number of machines, but they will be repeating their operations day and day and night separate that is a cyclic type of operations of that. The machine which is used the blasted or that fragmented rock must to collect that is called excavating and the machine used is called excavator. And then they take this material and put it to a transporting equipment that is what it is called loading.

So, this phase of operation is a excavation and loading is done by when there is a only one bucket that is called your single bucket excavator and that single bucket excavator is the shovel.

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Now, in our introductory class I have told that single bucket excavator has got this rope shovel hydraulic shovel backhoe front end loader and drag line. So, under this section we will be discussing about these machines and today is the first lecture will be on electric rope shovel which is a, electrically powered bucket equipped machine.

You can see here the machine is having a bucket this bucket which exactly collects the fragmented loose rock mass or cut a loose soil and then it is have to dig the material collect the material and then load and this work is repeatedly done.

So, this operation is basically excavation and loading and work in combination with dump truck. So, we will be discussing about this machines the in the photography you can see this is exactly P and H was a company which is, now taken over by Komatsu, giving a Komatsu P and H machine is a 4800 this particular model having a capacity of 65.7 meter cube.

Now, it is that say one single bucket you can think of a 65 meter cube, that is if you have that is if you are having a you can have an idea of your room if it is a or that is a 5 meter by 5 meter room, That is if you are having another 3 meter of height that type of room can be one bucket you can think of there, at least almost like a 5 meter by 5 meter by 3 meter rooms inner space is the buckets inner space almost like that. So, that is a huge bucket is being filled up and carried out.

So, we will have to know about this machines construction operation maintenance use and then you need to know that this machine it has not come in one day it has not developed like this as a machine, but it was a human concept and design which have over the years have evolved. From as the other part of our engineering science and technology develops the engineers for their operations make and design a new machine. So, we will be knowing about these machines today.

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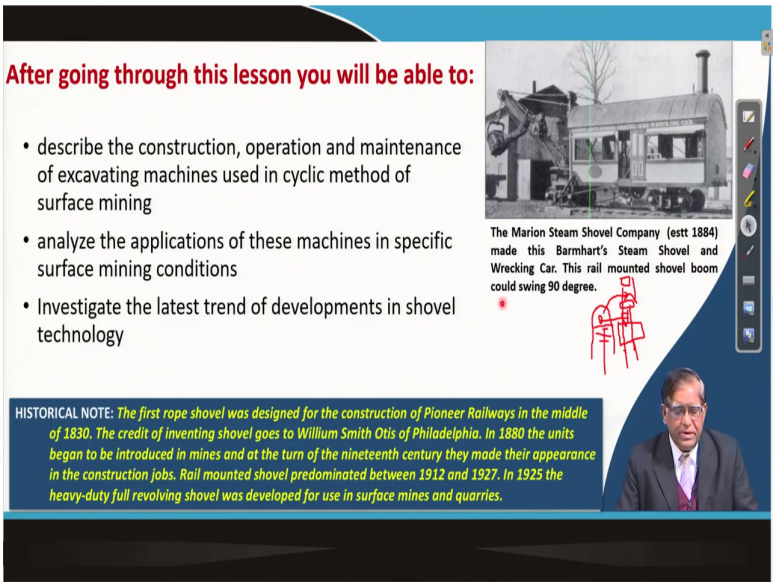

You can see here that how it came up in the 1884, that is a when the railway people railway was developed. In those days the Marion company it is also a big name in the mining machinery manufacturing, they started a rail mounted shovel. You can see here this is a machine with a housing it is in the just a on a rail it is moving it has got one from boom you can see over here, this boom and there is another this bucket connected with a handle, which is exactly having a it is suspended by a rope.

And then it is lowered and raised by simple mechanism and here it is exactly, when it is raised and lowered with the help of this rope and it could be moved forward and backward by a crowd motor they say or its a rack and pinion mechanism. Very simple systems in 1884 the engineers they thought of it.

And they were doing it in such a way that these boom they made it over a platform here this platform could be turn 90 degree, the turn 90 degree, so that it can take the material and load onto the roll.

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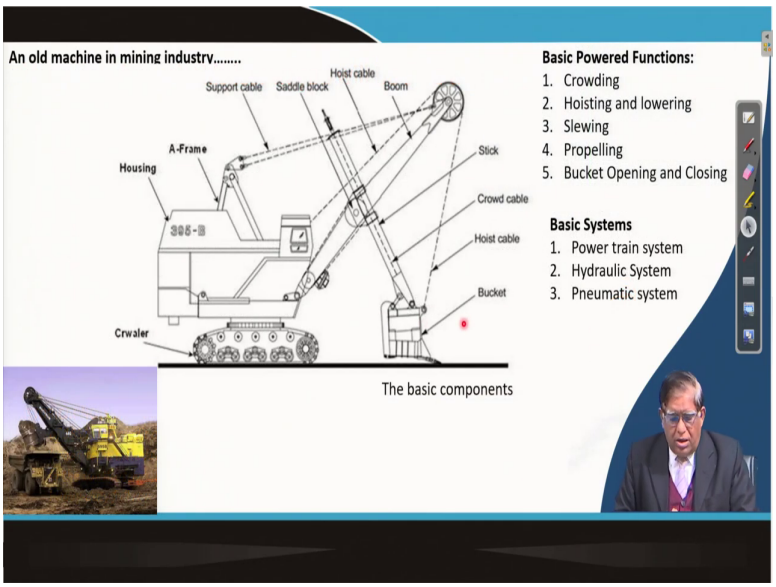

So; that means, if by the; that means, in that system if they have got the railway system here. In this particular rail mounted machine if you are having a rail on which this machine was a placed over here and this could this machine this boom which was here this boom could be made in 90 degree movements.

So, it could come over here and then it can make a 90 degree rotations and come over here. So, what was there because of this 90 degree movement if a loading machine is or the another wagon or the train is coming and placed over here, now if you are having this material

brought and then it is dumped and you have got a heap of material here; if you are having a heap of material here.

So, this heap material can be collected by this bucket and then it can be placed over here and this is just exactly the rail and then the steam engine is to come and then take this train away. So; that means, this rail mounted this shovel which is exactly working in this method.

So, you can see here that such type of system were developed in 1884. So, after this lecture you will be able to describe the construction operation maintenance of a modern shovel how it is there and then you should be able to apply analyze the application of these machines in specific surface mining conditions, and also you should be able to investigate the latest trend of developments.

And a, this one is you must understand that when the electricity came with this machines they develop with a very good electrically controlled machines and later on from the 1991 there is a with a better electronic devices came up and then we have got AC motors driven machines from the 90's they started.

Earlier from about 1920 to 1900 these are all DC motors were used in this machine. So, this is a very interesting piece of machines, which can be exactly which is which gives a very good very good understanding, that if you know how to select these machines how to operate this machine.

So, now let us come to this basic components of this machine. If you see here we have got this machine a shovel electric ropes shovel because the bucket is operated by rope it is called your rope shovel and it is the dump truck which is being loaded. So, this is excavating by the bucket and loading onto the truck. So, this is an excavator come loading machines.

Now, if you see a traditionally, that is the machine which has been dominating from the 1940's to 90 a type of design this is of course a, the 90's design that drawing which you are

seeing over here. We have got to see the Nomenclature how this machine is named that is the basic thing this bucket is also sometimes called dipper.

This is bucket and then this is called your stick or the dipper stick which is connecting. Now, this is a tubular one or in sometimes it can be also square, in tubular one we are having at the back by hydraulically moved this one is a hydraulically moved to one, but sometime it is moved by a crowd motor with the help of a rack and pinion arrangements over here.

Then there is a boom, this boom is fitted with a pinion here; that means, it can give a rotations that is it can be that angle of this boom can be controlled by means of a this rope you can see it is tight with that this is your boom point slew it is called this is a boom point slew, from here this rope is connected and then kept on a hoist winch are there that is a very high reduction ratio by worm and worm wheel type of gear you can just control these things as a very slow.

So, a narrow small few angles of movement lowering or that control of the this boom angle can be done which is basically a by mechanical arrangement, with that rope winch system that rope for raising and lowering this boom is connected to a winch here.

Then, the bucket you can see here this is called your hoist cable which is a wire rope you have studied about wire rope. Now, this wire rope it is exactly now this is the hoist rope is connected with a hoist winch here and then sorry you I just told you here this is a rope here, which is going for the boom angle, that is your control this is your you can see here as I told you that these rope is for your boom angle change and a this rope is for your bucket hoist and lowering.

Now, this is the A frame and then there is a housing and this is operators caving and these portions here there is a counterweight or that is exactly when you are giving over here the machine will have to be balanced. So, that is and then this machine is a crawler supported crawler mounted machine a crawler is there and then there is a turntable, on this turntable this machine can give a swinging operations.

So, now, you know that the basic components is we are having a undercarriage a crawler mounted machine. So, it is a undercarriage on that there is a turntable this turntable will be having a ring gear on that ring gear we are having a gear engaged which is mounted on this housing, which is rotated by a hoist motor.

And then there is a boom which is connected with a rope to change this angle of the boom and there is a dipper stick connected with a dipper or the bucket which is hoisted and lowered by another hoist rope connected to a hoist winch or; that means, there is a drum on the drum this cable will be rotated and the drum will be controlled by DC motor or AC motor to a nowadays and then, there will be the whole breaking and other old systems will be there.

So, the basic powered functions of this is called crowding; crowding means pushing this boom downward that is called your crowding you are giving a push to the material. And then there is the hoisting and lowering; that means, this bucket can be hoisted, now if you highest; that means, at this point it is fixed if it is going over here now with this radius this will be giving a turn like this.

So, that is where how exactly it will be giving a turning from here to here. So, that is that how your bench slope angle will be maintained depending on that you are this boom land and then this operations.

Then you can see that the other motion is called slewing motion, that rotating around the axis of the machine that motion is called slewing motion and then there is a propelling the traveling of this by this is a self-propelled. So, it will be traveling on with the crawler mounted machines.

And then these bucket it has got the backside a door is there now the opening and closing of this. Now, here we are having ledgefree in some old machines there will be another small motor here and the rope will be there by pulling that rope this bucket backside door will be getting open.

Now, here we have got a different systems by which called it is called your ledgefree; ledgefree bucket those type of buckets are nowadays coming. So, that way controlling from the weight and by hydraulically you can operate this bucket.

So, there are these main powered functions you have seen and we have got the mainly electrical power system or diesel power system this machine can be if it is a electrically powered there will have to be a supply trailing cable will be coming and giving supplied to a transformer mounted over here and then the power supply will be distributed to different motors.

In case of hydraulic system there will be the power either a diesel engine or an electrical cable power will be coming to the machine by that exactly a hydraulic power pack will be formed and the pressurized fluid will be sends to different things to make a hydraulically operated shovel system that is there.

But in an electrical system also there are hydraulic power required for many lubrications and all that gear pump or this lubrication oil pumping these are done for that a hydraulic system is there. And then there will be a pneumatic system that is sometimes for a compressor for cleaning and other braking operations and also can be done. So, there could be these systems which you studied in the basic elements that are there.

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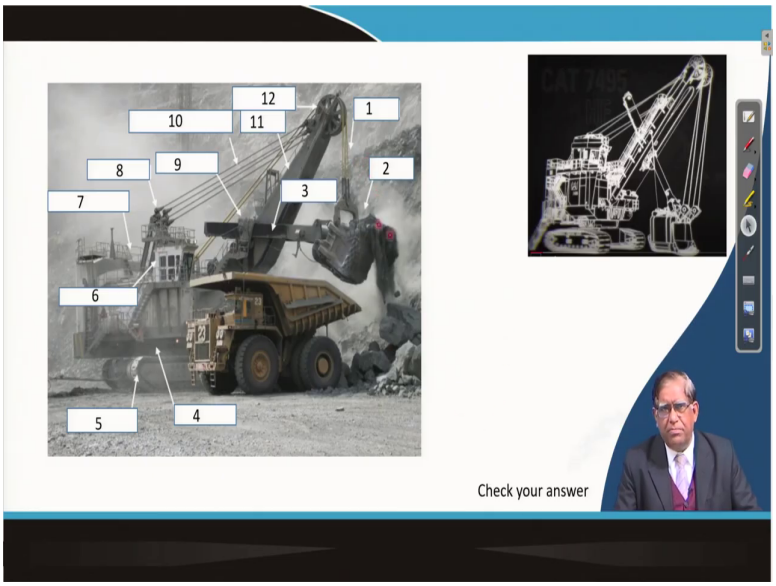

Now, you can see here you can give this exactly you can now tell that what these equipments are. So, now, can you? You can check the answer in the power point you can go and click over here and you can go for finding out what are the answers should try practicing over here. So, in this machine you can see here at the bottom side a rope is coming over here this rope is connected to this door.

So; that means, when this bucket will be placed over the dumper this rope will pull and then this door will get open and the material will be placed over there dumper. So, that is what exactly how the interior design look like.

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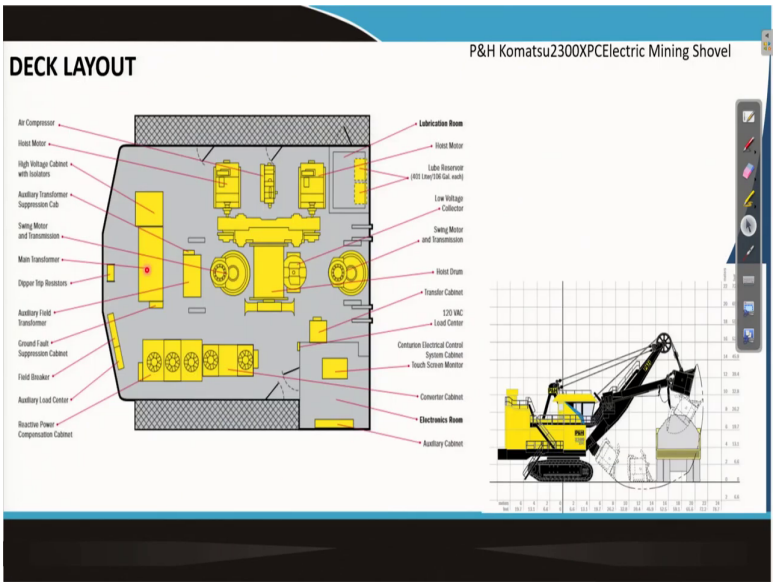

So, now there is a deck layout given over here; that means, that machine these housing you have seen in that housing over deck inside this housing on this turntable or the platform what are the things they are inside this machine. You can see here this particular room is a lubrication room, this is a lubricant room and then this is the hoist motor you can see this hoist motor is located over here.

Now, that motor is connected with the, this is a gearbox. Now, this there are two tandem drive is there this hoist motor two motors are there and then this is giving to this drive to that gearbox. From that gearbox we are coupled with a good coupling you are a getting this hoist drum and on the drum your wire rope will be there and this wire rope will be going it is coming out of that and these rope you can see over here and it is connected to this bucket for hoisting lowering purposes.

Similarly, there all the electrical purposes there is a, your high voltage cabinet with isolator you can have over here and then there is a main transformer which is placed over here. And then they say there will be the trip control all the controlled contact and release will be kept over here and then there will be a compensation cabinet, because wherever there are induction motors are used there will be because of the power factor to monitor there we can have a compensation cabinets and things will be here.

And then there is a motor swing motor, this swing motor output shaft is connected with this sun gear or the turntable are there. Now, when the swing motor will rotate it output shaft that a gear it will be matching with this a sun gear allow around this turntable over here and then the whole machines will be moving. So, you now know that in a machine how the different controlling things different components are housed.

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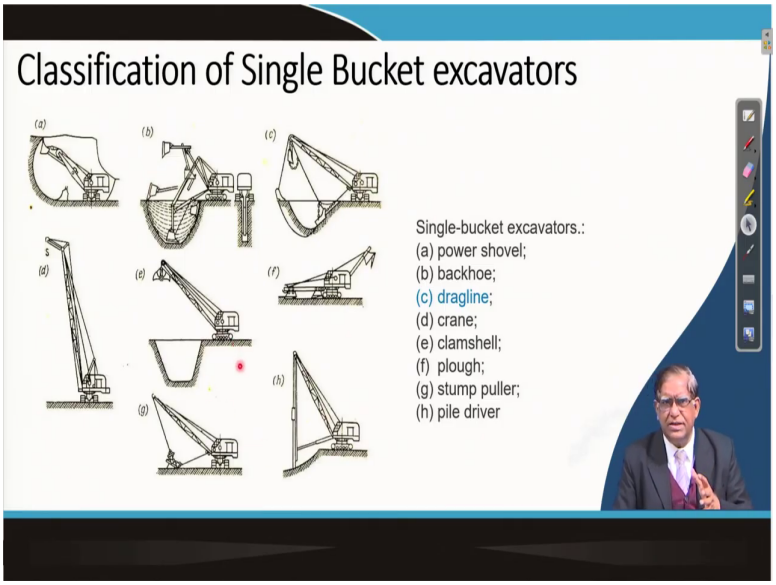

Now, once you know about that this is the basic of this that exactly there are a wide varieties of such machines can be there. The basic because this is a shovel you can see a power shovel where exactly this is a very long booms are there they cut and then the material they can cust to a far distance that is called your crowd or the power shovel is there.

Then there is also a backhoe where this is a shovel that a big single bucket excavator, but it is a hydraulically operated and it can work in a backward manner that is called your backhoe. There is a drag line which is also a single bucket excavator we have got a, this is a crane sometimes it is to you can collect a grab bucket over here. So, that the material can be grab like this particularly, they use in ship unloading that is a grab bucket will take the material and then they will put it over there.

That is also plough which can exactly get the cuttings there scraping extents can be done these machines there, if you collect the plough type of things it will be ploughing as a scraping. And then there is a stump puller for the trees stump taking out for this purpose also that same basic excavator component things with the rope and winch can system it can be used over there. There is also pile driver in a civil construction work. So, this is a class of machinery which are used for your general knowledge I have put it over here.

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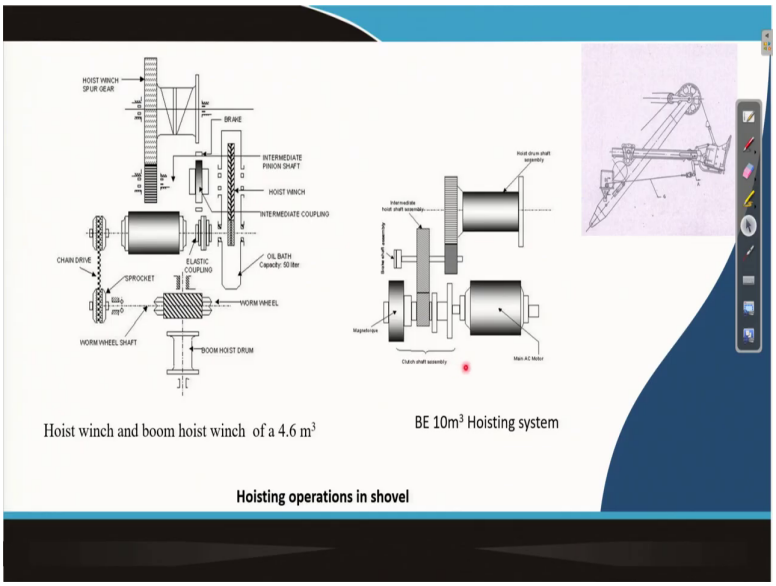

But, the now knowing about the machines how exactly the different operations take place. Say for example, you can see here in this diagram this is the boom and that we are showing a old version of this is your bucket which may be say 4.6 meter cube or 6.3 meter cube capacity small bucket.

And then you can see here there is a less back less is there and then there is a this stick two sticks are there, that is exactly this boom is going just like in between the in between this sticks and that is exactly, we cannot.

Now, what is done this bucket stick it will be moving on the basis of this a there are rack and pinion it can move over there. Now, how this hoisting operation is done? You can see that there is a, you have got one that your hoist motor which will be exactly running day through these gearboxes.

So, here we are having a flat that is your elastic coupling with the drive motor you are having this gearbox connected, now that gearbox output shaft is going through this and then it is connecting to this pinion and then it is connected to the that your hoist drum is kept over here and the rope is wound on this. So, this rope is, your this hoist rope which is connected.

But, that from that motor another portion of this with a chain drive it can take it to a sprocket and then you are giving to a worm and worm wheel and where we are connecting a boom hoist that earlier, I said that the your boom also can be raised and lowered.

So, here by this two method that is using the chain drive and also by the worm and worm wheel you can make this drum to rotate at extremely slow rate and by that exactly boom will be moving very slowly up and down, this is how the kinematics of the hoist system.

And, then here is the how exactly they in a modern machines we are not having those gearbox only over here. And this is the motor with a series of this gearbox you can just drive and control this modern. So, simpler designs are also there.

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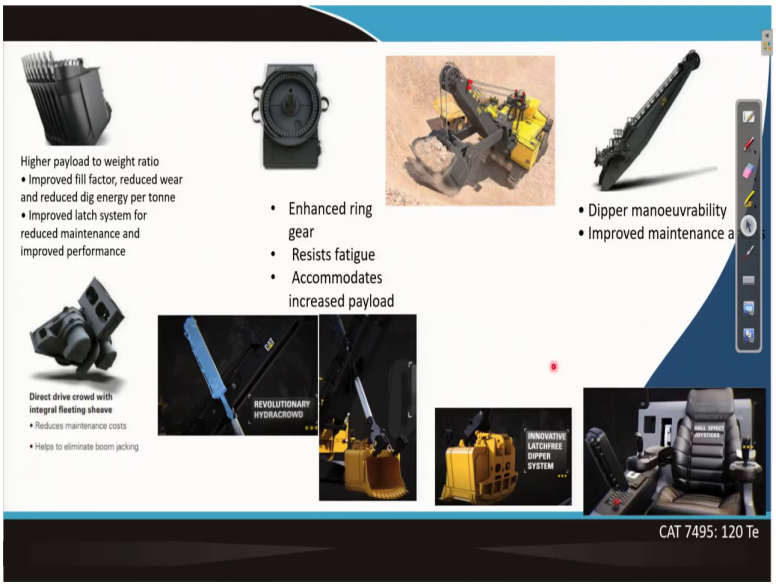

So, you can see that the different components, which have come in the modern machines I told you about this or P and H your design; P and H Komatsu designs. In which they have got a big higher payload bucket they design the bucket to take a big load.

And then this ring here which I was telling that whole turntable is mountain over here this has also because such a big machines will be having a huge quantity of load is coming and with that load it will be slinging. So, that turntable will have to be designed very effectively, then this boom dipper stick can be having a hydraulic system at the back and it can do it.

And you can see that this your earlier that boom which was having a guard guarded type of cross sections with that has been coming with it tubular hydraulically operated. This was your

that is your, the boom this stick was the raising and lowering that was done by a crowd motor over here, but that can be done by a this hydraulic systems over here.

Then this is your less free that is no rope is required to open and close this bucket that is there. And you can see the modern machines that operators cabin it is operators chair is a very sophisticated comfortable chair and now it is with the modern big machines instead of one there are also two other operators can be sitting by the side of it there is a sitting arrangement there so that they can be trained that is new operator to be trained while sitting over here those type of arrangements have nowadays come in the modern things.

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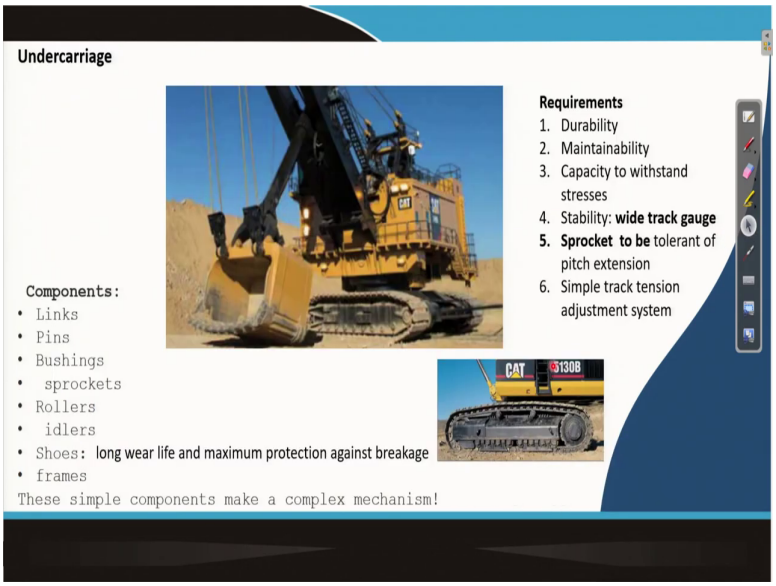

Now, you can see that under carriage we have said, now while designing that in a shovel the undercarriages should give some of the property. When you are going to deploy these in

mines you know the mining conditions you can see at the background it shovel and then it is under the sun and rain and storm whatever it is.

So, it will have to be durable it will have to be maintainable it will have to have the capacity of which then different stretches on it and then there will be a, that that your machine is a heavy weight.

So, the crawler will have to be a wider show that the total pressure coming onto the ground is less because if the total pressure on the ground is more than the crawler will shing, sting shink on it. Then there will be more resistance to propel this machine and sometimes the machines will not be able to work a longer time.

So, that is why these are the arrangements to be given, but that crawler which you see it is a very very important equipment this crawler which looks it is a very simple it is a parts only link a pin bushings sprocket roller grader shoe these are the components small machine elements which can be designed at any as MSME, which can be done.

But, when they are put together you can see how complex operations can be done in a very gigantic giant machines like a electric ropes shovel of 6570 meter cube capacity that is, which will be able to take a load of say 120 ton; 120 ton of material can be cut excavated and loaded in every 30 seconds. The cycle time of each operation that crowding hoisting, then stringing unloading then again coming back and then putting.

So, remember that what is the cycle of a shovel operations? It is giving a crowding instead of taking the material, while it is hoisting material is loaded into the bucket when the bucket is loaded of the excavator it will swing with load then it will be placed over the dumper main material will be dumped over there, again that bucket it will swing it back and after swinging it back it will be again positioning for doing the next cut. This is what is a cycle of sequence of operations.

Now, there this crawler will be moving when one faces that cut machine is cut then crawler will be moving over there. So, this you can see that in the dozer you will be finding that in

your there crawlers are having a grousing crawler, but here you can see the crawlers have got preserved it.

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So, you should identify that the crawler depending on the type of machines different crawler are under carriage in mining is different. So, you can see here the ropes shovel it is a very flat one and that is why this that your operations of the floor should be smooth.

But, if you see a drilling machine which also work in a area where that is exactly the first you need to work on you need to go to a rough places thats why there is a grouser. You can see here in a dozer they have also grouser type of track the track exactly is a huge things in which there different plates are connected together by a pin.

And that is where how our; in a hydraulic excavator also you can see that electric rope shovel they are heavier because they are very weight is more that is why the crawler is having because the mortar then generator then other things are there, but in hydraulic excavator their weight is comparatively less that is why you can see the crawler is also of lower weight.

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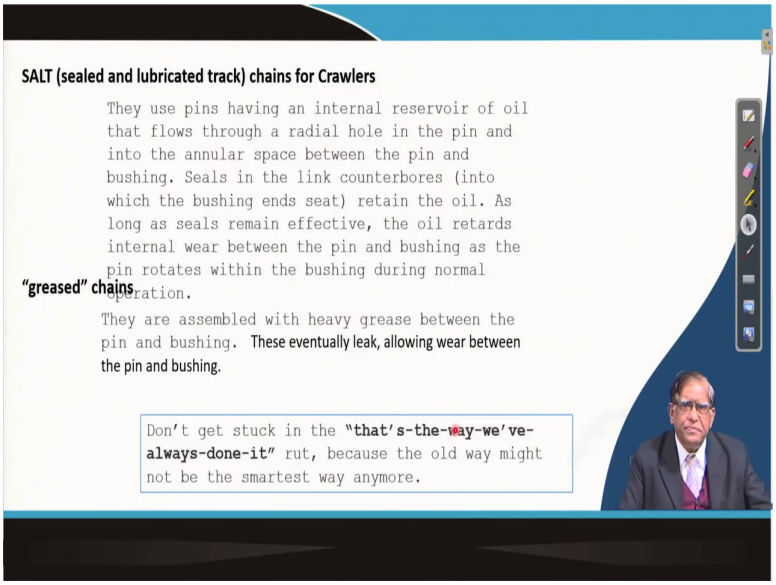

Now, if you see that there is a distract is coming with nowadays is the design feature is the salt track that is salt crawler chain means sealed and lubricated track that is the pinch and all it should be properly lubricated so that we are does not take place.

If the crawler chain breaks because of this wear and tear then it will take a long time to set it right and there will be a production loss that is why the in the design itself it is taken. So, that the lubrication is proper. So, wear and tear of the pin and the chain will not damage for that

purpose these are the innovations were done which is called sealed and lubricated track you can read about it.

Similarly, that to lubricate sometimes that they are there are grills grease chain or the track is already it is having the grease is kept over there and then it will be oil operating it will get lubricated.

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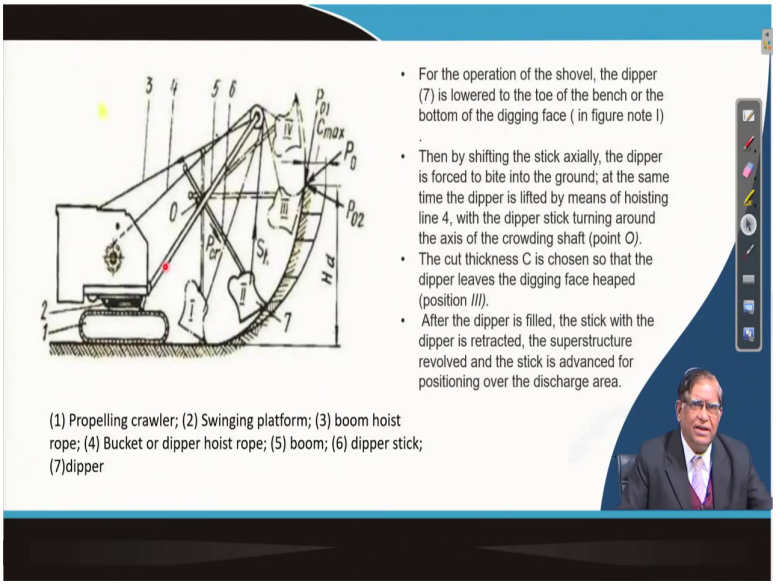

So, this type of arrangements are there and now the operation of this machines how it involves. You can study about that this is a the propelling it will come over there that this it is placed in such a way that when the boom is kept particularly down at this point you are cutting touching the toe of the your slope. And from there when you start raising or hoisting at that time this curve will be made and this is the 90 degree after that when the your boom is 90 degree to its original position.

So, these must while it is going like this then it will be cutting this cross section of material, which you can see over here. So, you can see that this machine it can come up to a particular bench height on lead can cut above that it will not be able to cut. Because it will be done the teeth will be going outside this. So, that is why there is a, every site the geometric locations that depend on this.

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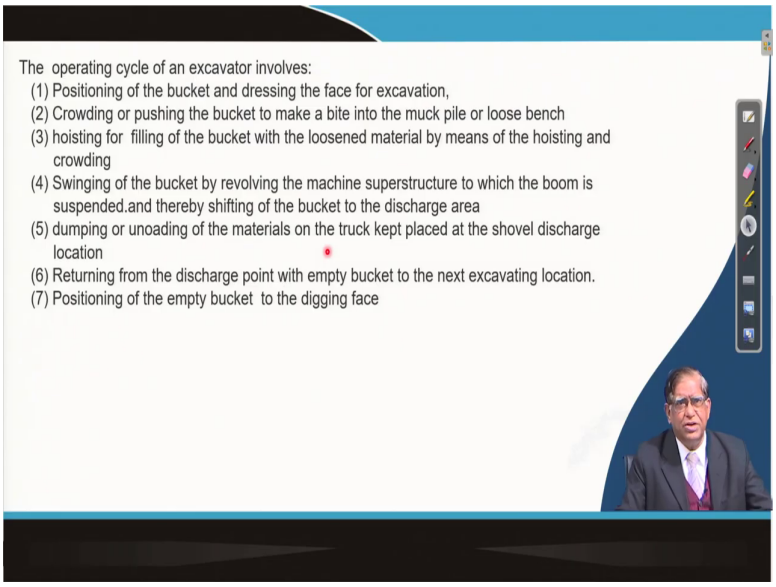

So, now it is clear for you the operating cycle of an excavator means first you position, after positioning you crowd after crowding you hoisting and filling with these and that loaded then swinging back and then again the swinging and then dumping and then swinging back and then again returning to this. So, this you should be able to explain this say your cyclic operations over here.

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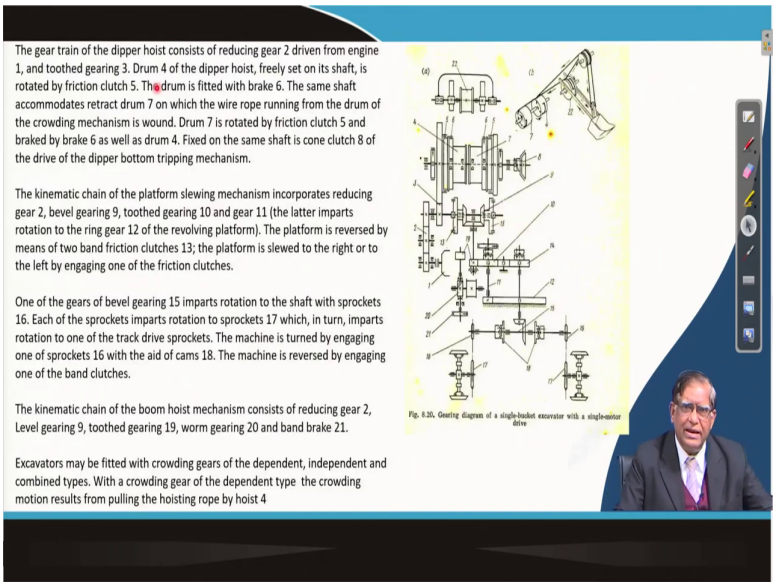

And now to do that I have given in the power point you will study that this is called your cable riving, how that cable or the wire rope will be going and how it is being laid over there in the machine is called cable (Refer Time: 35:07). Make to make design to design this kinematics are different for traveling of the machines that how that steering will be done that is also can be change. So, that make to make machine to machine things will change, but the basic things are the same.

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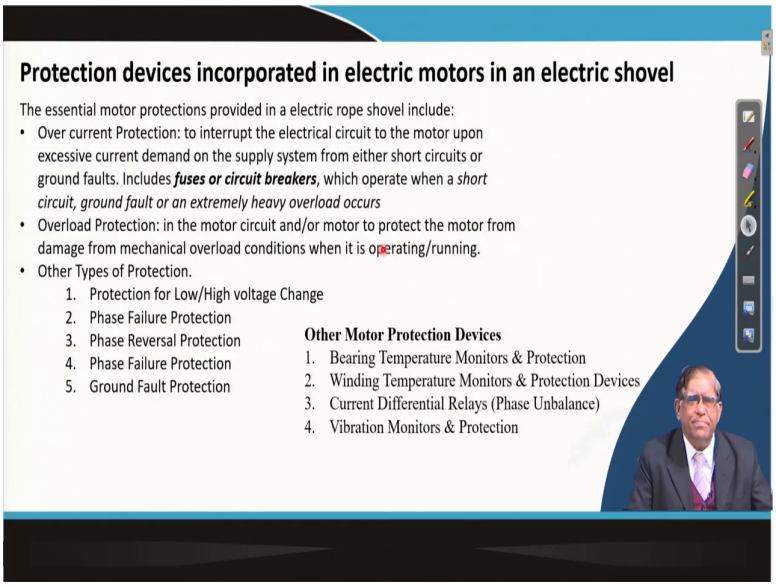

So, there are lot of electric motors in electric group shovel as you say. That basically in earlier time what it was there, that the your high voltage about 3.3 kilo volt, but this, but will be brought them in it will be converted to 450 volt and that induction motor will be running to generators and that generator will be running the, there will be DC generator there will be sling motor and all other motors at DC motor will be provided supply from that DC.

Now, in this system that from the 90's it got changed then that came the, this AC motors. And then this AC motor control that whole machine in the control systems in electronics they changed and that is called your now IGBT that is your insulated gate bipolar transistor, which was introduced in the 90's and that insulated gate bipolar transistor they made these electrical control smooth.

So, basically a machine to work you will have to know little bit that how the electricity is a provided and then you are when to make a safer operations your these motors will have to be kept safety safe. Safety operation of safe operation of it would done to prevent the downtime of it that how the motor will be protected about overload, how the motor will be motor will be protected over the over current those issues also will have to.

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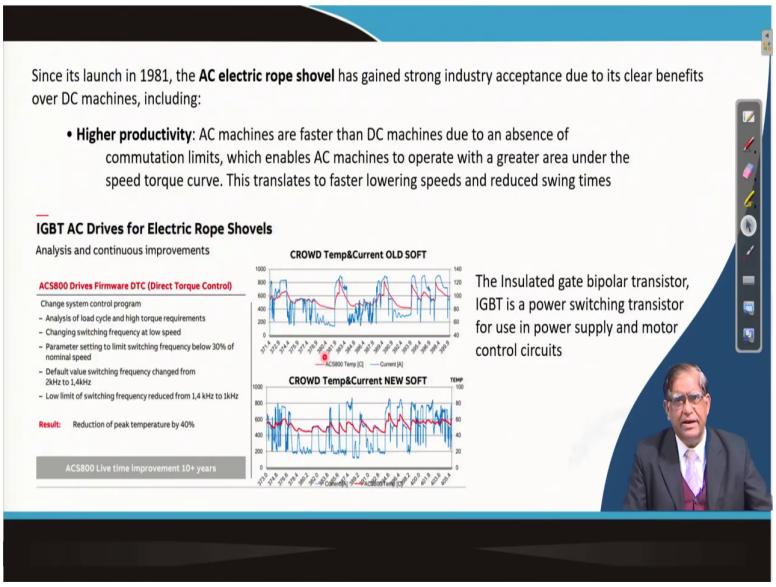

So, here you will get an opportunity to revise back what you will learn in your second year classes regarding the electricity. So, that one you can see that when you are using these IGBT, by use of IGBT these undulated powers that is a way the temperatures of the motor get changed because of these undulations it can step down and made it smoother by which the motor life and the control and the things becomes much easier.

So, now, this ultimately when you are properly controlled motor with a long life and then your mean time to repair of a particular fault is a reduced or the mean time between failure is increased by doing a proper design and the component improvement your shovel productivity will be increasing.

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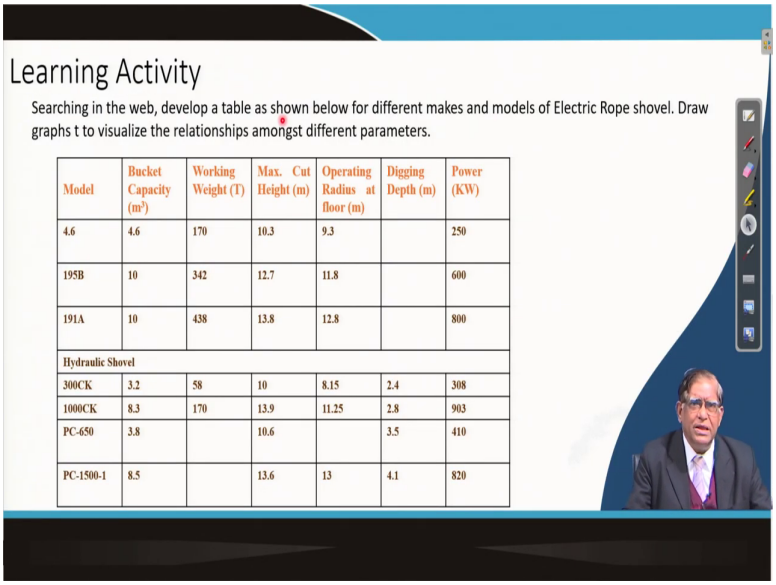

So, here you will have to do a learning activity just searching the web and develop a table as shown in this table I have given you an example. So, here you can see the bucket capacity I have kept it up to 8.5 meter cube. And in India in the 90's late 90's the 10 meter cube shovel came in the early first 5 years of our operations 20 meter cube shovel came, then in the that is during the last 10 12 years we are having up to 42 meter cube shovel in India.

Which is operating in southeastern coal field of India, where that in the Gabra and (Refer Time: 38:30). So, this has gone up to 42 point 42 meter cube shovel loading on to 240 ton of

dumper. But, in the world we have got up to your 75 meter cube, around 75 of meter cube of shovel loading to a dumper, which is coming even more than 400 meter cube of capacity.

So, this table when you will make it this will be you can visualize the data that is when you are the bucket capacity and the power kilowatt how they are related. Are they exactly is the relationship uniform that is your meter cube per kilowatt hour is it exactly increasing or decreasing you can make out that whether the operating radius there is how much exactly more area you can cut from one simple positions so many analysis of the data you can do it.

So, this type of data are available. So, I have given you an example of this, please make this table with the all latest information of high capacity. You go to the website of Komatsu and caterpillar that is a, you will be getting then. You could also see some of the older machines like your (Refer Time: 39:54) company's machines Marion's machines then your P and H machine.

And in this scenario in India they were manufacturing electric rope shovel in collaboration with Russia by heavy engineering, corporation of Ranchi. And then it was in the 80's up to 80's there were a very good performing machines were there, but unfortunately our country was not ready in producing hydraulic shovel.

But, in the 80's they introduced hydraulic shovel in our mines and they stop procuring and stop encouraging the electric rope shovel though there are this life of a, electric rope shovel is supposed to be 12 to 15 years, but there are machines still that when HEC produced machines with Russian design up to 25 22 years it has worked.

So, there were a very good engineering and workshop at Ranchi, but somehow we have not maintained that. And then in there is a different chemistry and different eco system that our Indian manufacturing did not come, but you please check that what is the world scenario now. And, nowadays also our HEC Ranchi they are manufacturing and some of the hydraulic excavator sites and some of these our Bharath earth movers limited BML they are producings.

Other than that some small companies are also venturing a assembling some of the frame equipment over here in the country. So, once you do this study you will be having a proper data analysis for knowing the situations in India. It will be another exercise you can do it that where you stand and what you can do.

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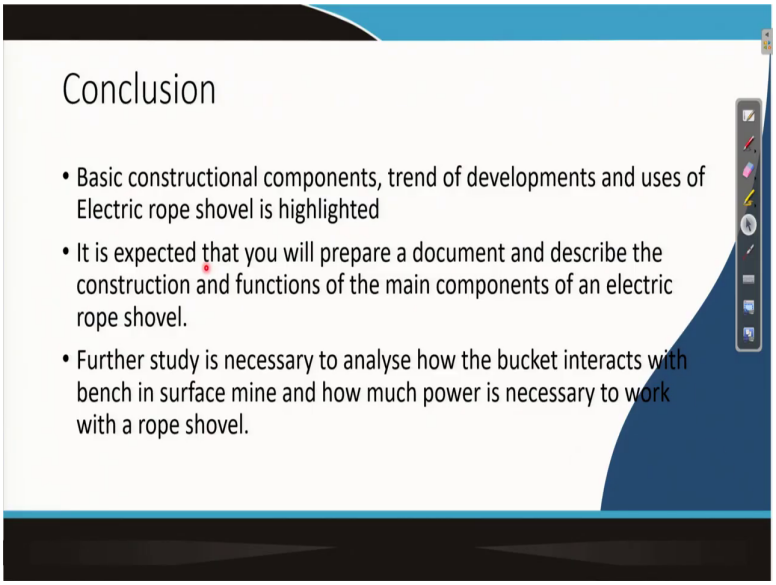

So, basic constructional components trends and development of this use of electric rope shovel we have just highlighted here. It is expected that you will prepare document and describe construction functions and main components of electric rope shovel. Further study is necessary to analyze how the bucket interact with the bench in surface mine and how much power is necessary to run a surface mine.

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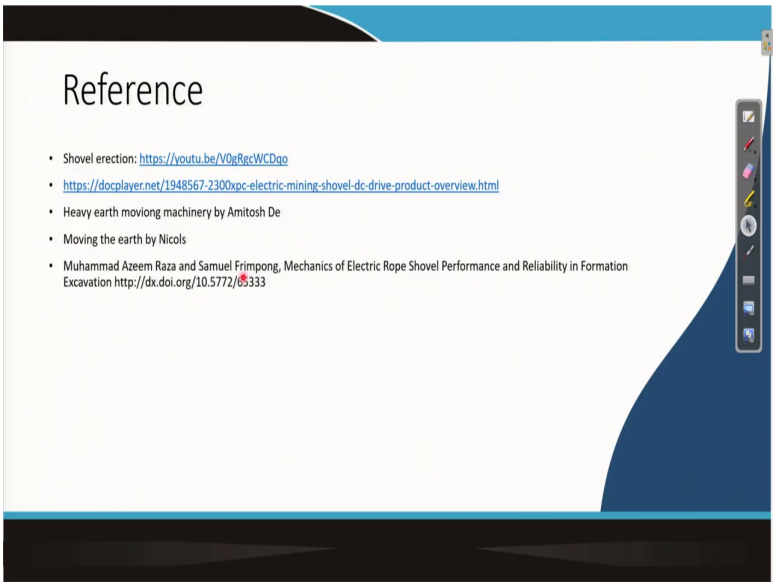

So, there are many interesting research has taken place for the productivity for the cycle time and then for the matching of shovel and dumper so many things. But I request you please read this Samuel Frimpong, that is you know that Samuels work are very good in the mechanics of this earth moving he had discussed.

So, I have given you the reference of one of the paper of professor Frimpong, what you should do you please try to do the take the diagram from the article and make the analysis by your way and you see that you can develop a new model out of it.

Any one of you want to do a mini project on analyzing the kinematics of shovel electric rope shovel exactly what are the cutting forces coming in front of the teeth and that exactly if you have to design the teeth of a bucket of a shovel, then how it should be there.

You should make a study whenever you go for a site visit with a shovel operations look at how the teeth can life can be improved how the bucket life can be improved how the crawler life can be improved and for that what type of monitoring and data collecting should be there. So, that we can acquire that data and we can give a good machinery management input to the industry. So, there a lot of opportunity and scopes are there.

Thank you very much.