Mining Machinery
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Module - 05
Lecture - 06
Surface Mining Machinery
Machinery for Continuous Excavation: Bucket Chain Excavators

Welcome to today's class. In the last class, we discussed about the Continuous Excavation Machinery – the Bucket Wheel Excavator and there we mentioned that the other type of continuous excavation machines are bucket chain excavator and also we have got continuous surface miner. Today, we will be discussing the Bucket Chain Excavator.

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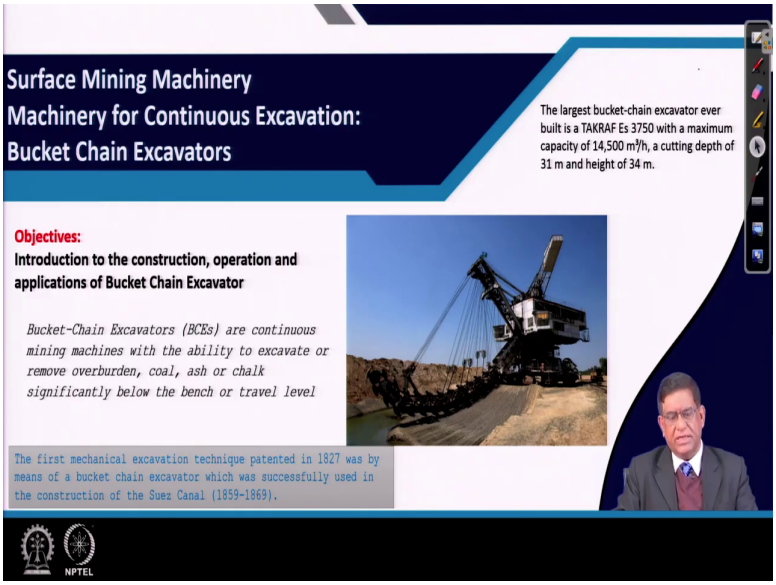

Now, as you know that this machine it is a very old machine rather it was the first mechanized system it first designed in 1827. And, this machine a bucket chain excavator was used during the 1859 to 1869 when this Suez Canal was. Now, today we will be discussing about the construction, operation and maintenance of this machine and we will tell that whether what type of conditions we can use this machine.

But, while discussing you please correlate this machine with the bucket wheel excavator which you have already studied. Now, there is a difference in the bucket wheel excavator and bucket chain excavator, in the sense the cutting the that there is no bucket wheel. So, you can just think that this machine is almost similar to the bucket wheel excavator, but instead of the bucket wheel there is a bucket-chain that is with a on a ladder.

As we will be discussing over here that the front attachments that where the main cutting things over in this machine is on a bucketed on a chain. And, this machine is manufactured by number of companies of that this TAKRAF is one of the company, which has produced this machine and working in Bulgaria, working in Siberian hard coal mining. So, it is also used in another form that is another machine called dredger. This dredge which are used for underwater excavation.

There also this machine with a little bit of modifications they are used. There are quite a wide range of varieties available in design and that is depending on the conditions it can be tailor-made and then you will just see what this machine is. You can see also that this machine is also another very giant machines in a huge machines with a very heavy weight. There is a 5000 ton weight machines of this bucket; bucket-chain excavators are also available.

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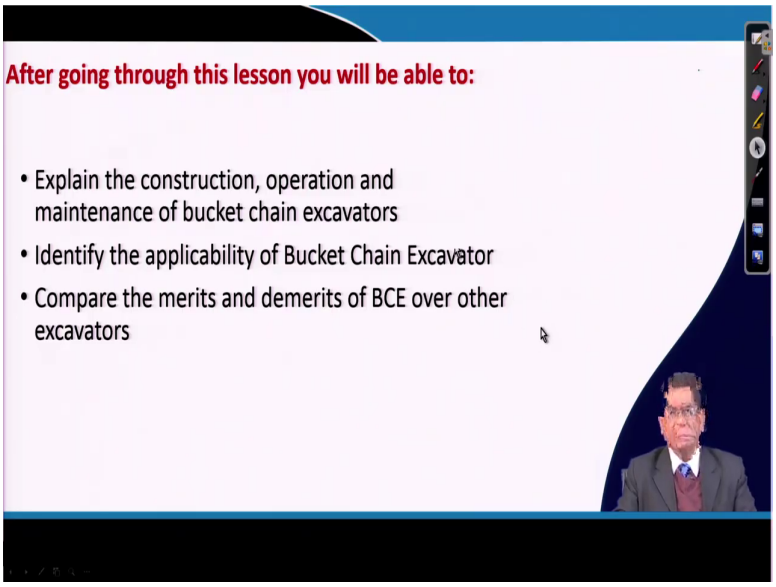

So, let us see about this machine and our after going through this lecture you should be able to explain the construction, operation and maintenance of this machine. And, you must be able to identify that what are the applicability of this and you will consider the different operational parameters. And, then you try to determine what are the merits and demerits of this machine compared to the other excavating machines you have studied so far.

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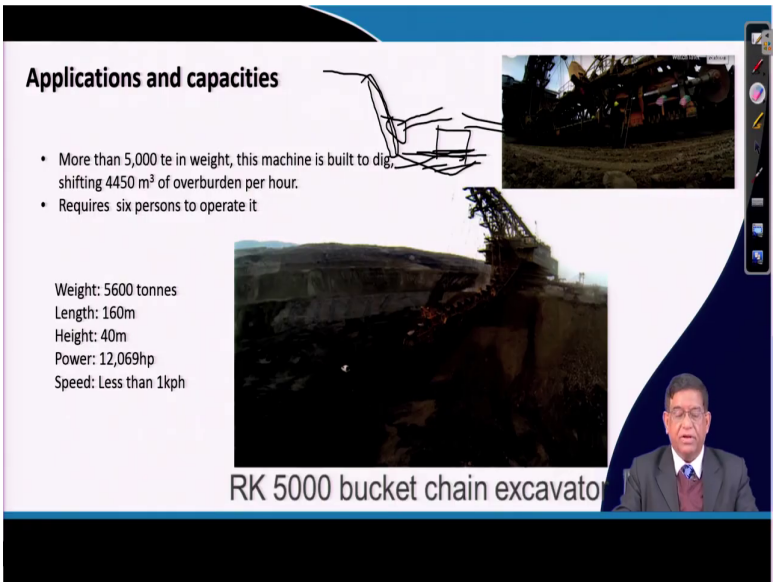

So, let us see this figure first. You can see from this that it is applied by cutting from the below it is mounting positions. Just think of what you studied in bucket wheel excavator. In the bucket wheel excavator you have got the machines that is if you are having a mining phase like this on there your machines bucket will excavator will be placed on this floor of the on this floor of the pit.

And, then it will be having its bucket wheel which will be cutting over here and then this bucket wheel will be having a boom and then this will be discharging to another boom. So, you can see here that is above the crawler level or the mounting level you are cutting this bench in case of bucket wheel excavator, but here in bucket chain excavator your machine is sitting on the top of the bench and it is excavating from the bottom.

So, that is two differences you have already found with bucket wheel excavator one that is bucket wheel excavator has got a wheel and here there is a bucket wheel boom or the receiving boom. But, here we are having a ladder that is just like one ladder which is also raised and lowered by this winch, rope winch system this whole ladder can be raised and lowered and on that we are having two sprockets on which a chain is moving on this ladder and on that chain this buckets are mounted when it is rotating in the opposite directions. You can see this is also another difference.

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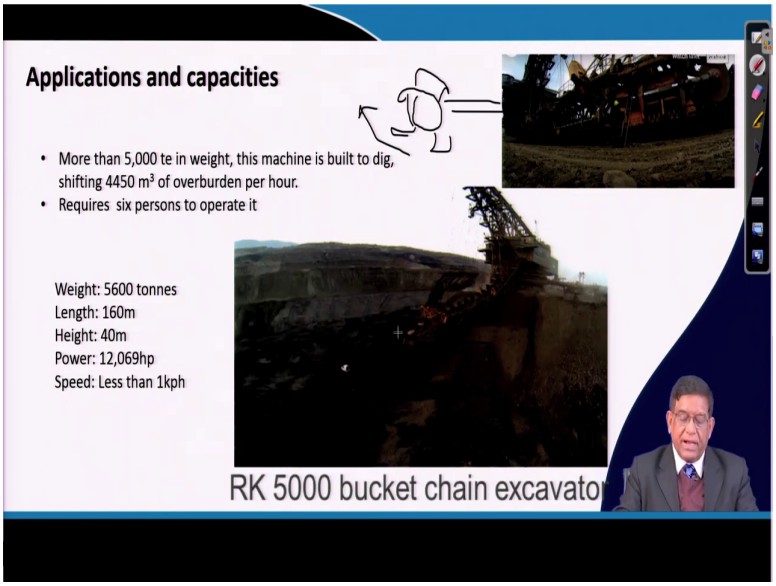

In case of bucket wheel excavator, you have seen that is that bucket on the wheel your buckets are mounted like this and then your while cutting this was rotating in these directions. So, that the material was thrown from the bucket onto the conveyor belt here. But, in this

machine the rotation is in the opposite direction. It is rotating in this direction that is towards the buckets are cutting towards the machine.

So, these differences you please note it down. And, then you can see that these machines can be very heavy as the specification says for one of the machine 5600 ton and it is capable of exactly taking 4450 meter cube of overburden per hour. So, it is a very high capacity and the machine height is 40 meter. You can imagine compared to bucket wheel excavator they are also 30 to 40 meter height.

So, the power consumption that is install power that is we are having 12,069 hp install powers are there and it is this machine is movement is very slow compared to the bucket wheel excavator and there is a different type of mounting is there you can see over there. So, this application is normally for where there is a loose alluvium type of soil or where there is a underwater deposit there you can use this machine.

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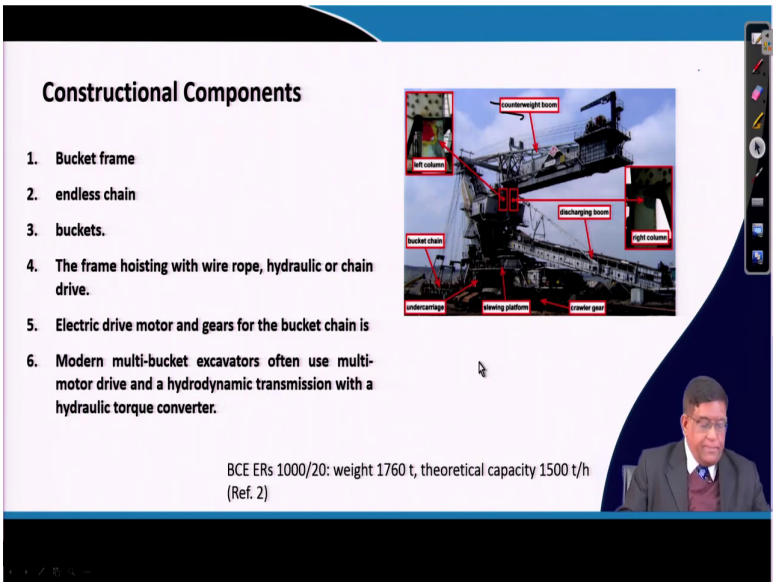

So, you can see the constructional component of this machine is there is a bucket frame or ladder which is on which you can see here in this there the bucket chain is mounted. Then the machine is also this endless chain and this bucket that is discharging the material on a discharge boom where there will be a conveyor which will be loading.

Now, this whole part upper portions there is also a counterweight boom like bucket wheel excavator and then a pylon structure. So, that these rope winches are there from here and you are having the winch motor mounted on this. This upper portion is called your superstructure and there is an under carriers, these under carriers or the traveling gear you can see here it is mounted on crawler in this particular model of the machine.

Nowadays, you can note it down that the constructional components mainly the bucket frame, chain, buckets that is your frame hoisting with wire rope, then your electric drive motor and

their gears and all that things are mounted on this and then there will be different type of control systems. Now, these controls electric cabinets and all the kiosks and panels are kept at the counter weight boom.

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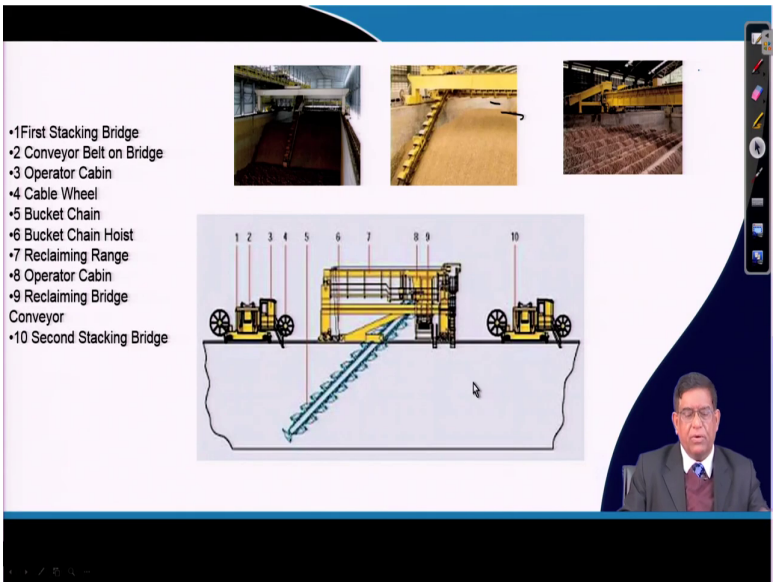

So, this machine they can have the theoretical capacity vary model to model, place to place as requirement of this. So, here as we said that this machine is electrically operated the this huge machine when it is to move and all then the electric power is brought to a separate trolley on which this trailing cables are reeled and from that trailing cable the power is given.

So that, that means you can operate this machine you can see here as a model that is it is digging from the slope. It can just taking the material from the slope and then it material is transferred. So, while studying this machine you will have to know that how the material flow

is arranged that is the material transfer rate and that this how engineering way you can put it that is the most important things.

So, you can once again look here that is your there is a your stacking bridge on which this exactly the whole that cable reel it will be keeping the cable on it and there can be a conveyor bridge; that means, from the material from here from the slope it is collected and then it is given on this conveyor belt over here.

So that this conveyor bridge there is a material when it get transferred that conveyor carry and then discharges on to another conveyor belt below it and then the material could be taken it out. So, that is one arrangement is there. So, this machine is sometime used in the reclaimer mode if you are having a in house this is you can see that this particular application is shown as a reclaimer mode.

This bucket-chain excavator can be used for reclaiming the stored material. Sometimes it can be used even for that emptying or taking out the material from budge or the ships. In a ship unloading system there also this bucket chain excavators are used. So, you are finding it I think you are noting it down the applications can be in mining or it can be in dredging or it is can be used on reclaiming and ship unloading.

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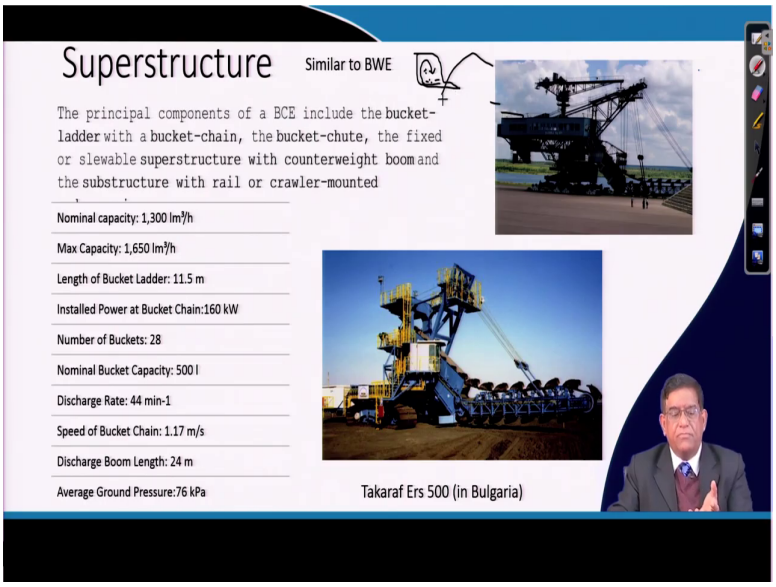

So, this machine so that means, there is a superstructure that part which is being placed over the travelling gear or the undercarriage, this upper portion is called the superstructure which can be slewed. So, that means, there is a turntable on which there will be a sun gear and it there is a bearing, on which this whole upper portions can be slewed.

Now, in this figure it should give you a clear picture that this ladder, which is mounted onto the superstructure at the bottom and then it can be raised and lowered called hoisting or lowering and this motion is called that is it is a luffable that is called luffing motion means going up and down while it is in slewing.

Now, there are of course, in operational control it is there that which motions can be exactly interlock. Say for example, if your traveling is going on that is called your propelling motion

when the machine is propelling or traveling at that time you will not allow it to swing. So, that type of interlock systems are there in the control.

But, you can see here that the chain which is moving on to this sprocket at two ends and then there will be a sprocket here which will be exactly can be given the drive to that. So, that it is rotating all along this and when it is coming over here while turning it discharge the material which fall into a conveyor belt taking on this discharge boom and it takes away.

So, a typical some dimensions you can see of a Bulgarian machine which is a Takaraf Ers 500, that Ers 500 is a model built by this Takaraf company which is working in Bulgaria for handling ash fly ash and ash ponds. They take out the ash from there and then for that the nominal capacity is 1,300 loose meter cube per hour and then maximum capacity it can give 1650 loose meter cube per hour say it is a huge producing machine.

And, this bucket ladder you can see some dimension. This is 11.5 meter long and on which there are 28 buckets are there and then you should know now what will be the speed of that chain to get this type of per hour productivity, then for a particular bucket fill factor of a particular size of bucket this side we are having 500 liter bucket.

Now, if a 500 liter bucket mounted on a bucket-chain need to discharge your 1,300 loose meter cube that is this much material, then this belt will have to be or that chain will have to move at a particular speed you can calculate that speed and it has been found that it is the chain speed is 1.17 meter per second it normally varies in machines from 1.15 to 1.22 meter per second if chains are moved.

Because if the chain move very fast the bucket filling may not be proper because the bucket filling it will have, it will be depending on the cutting resistance given by the material, and then the type of the teeth and the shape of the bucket by which the while you are pushing the bucket into the or when you are trying to dig the material, the material will have to move inside the bucket.

Now, once that first some material get in then that material also will be giving a resistance to move and also at the backside of the bucket the material is coming and it will have to give a turn it back. So, that means, when a bucket is say if your a bucket is shaped like this if the bucket is pushed into this material, then the material will be flowing in and then it will have to go and then it will be turning like that.

So, that means, the while filling the bucket if already there are some material, this material will be giving a resistance to it. So, that means, the bucket filling time is required. If you are moving the chain very fast then you will not be able to fill up the bucket properly. Now, here comes that you can do a design that what type of if it is a free flowing shunt type of material and then what shape of the bucket will let you fill it quickly?

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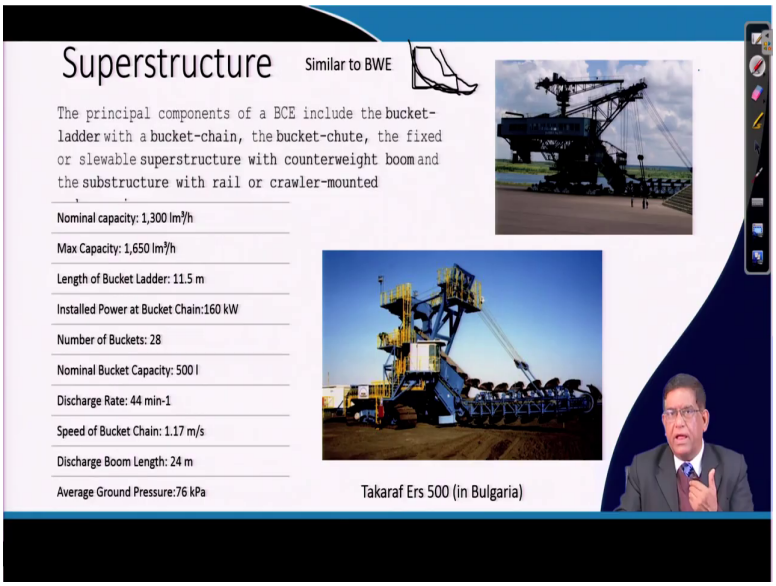

That means, the bucket can be of say that is a it can be a bucket of this shape or a bucket can be of a curved shape or the bucket can be of a shape with a giving a different type of curvatures over here. Now, what type of curve will giving you the best bucket filling for a particular resistance or particular cohesion or particular the that your strength of the material.

So, this is a research study you can carry it out and you can find out that you can optimize the total delivery; that means, if you are having the machines and then by changing the bucket you can produce instead of 1,300 meter per hour. If you can produce say 1,500 by the same machine, same power then it will be a productivity enhancement.

So, that type of study are necessary and that could be conducted by mining engineers. Now, you can see that this is your discharge boom that lengths of the discharge boom it is your 24 meter. So, total width of the machine you can find here that is 11.5 and 24 that is about more than 35 meter of span this machine is of a this is one of the smaller machine.

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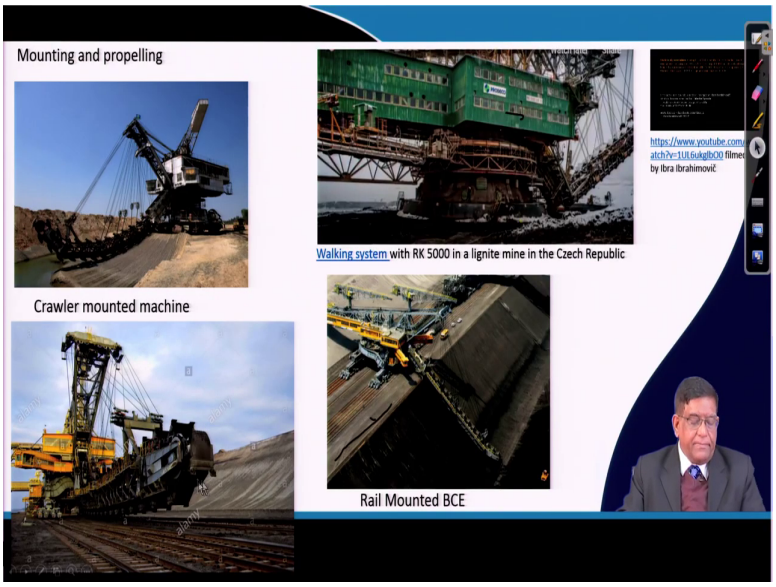

So, there could be now once you see here that the your how the machine is mounted for propelling purposes you have seen that there is a mainly crawler mounted machine. There could be six pairs of crawlers just like in bucket wheel excavators the three pairs, six crawlers, two will be the steering crawler and one pair will be your fowler crawler. And, there you get the three punch support and also with hydraulically operated steering mechanisms are there.

So, that the crawler mounted machines are replaced for a bigger machines that RK 5000 that a machine, which is working in Czech Republic is one of the largest walking drag line you can see that these machines RK 5000. You can see some YouTube video. These machine work in a different way. I do not know whether it will be working here.

You can see that this machine can work in a, that is you can see here that this machine can be operating on the on a top. If you this machine is simply working this top portions, which is there at the bottom it can be just on the hydraulically moving, walking pad there could be different mechanisms. But, this machines at a very slow speed you can see at the side image if it is visible for you or you can see in the YouTube that this machine is working here in the corner you can see or.

You can see in front of this machine there is a trailing cable that electric power is being provided on a separate trolley and then the power is given to this and that it is exactly electro-hydraulically moved machine which are huge machines, but you can see here when the machine is working at that time it is supported on a tub. Now, because this one is put it here it can work on loose soil that is the ground bearing pressure is very less there also it can work very effectively.

Similarly, other type of system which you can have that is rail mounted machine. A rail mounted you can see here in this particular the machine is supported on the rails on which number of these wheels are there on the rails and it is exactly cutting parallel to the rail. There is a less flexibility because it can work only along these ones and then it will be going on taking that is when the chain will be moving, it will be collecting the material and then when it is moving forward that a strip is getting laid.

So, that means, the whole face this face will be advancing in this directions. This face is advancing in these directions, what it will do? The machines will be moving in these directions. Now, when one particular strip is getting cut by the and then this material that to which depending on the bite that is giving you are cutting over there and then you cannot make it move in that directions.

You will be cutting all along here and after you go to that end then it will be going back again over here. And after some time these rails and all will be shifted towards these directions and then the face will be advancing. So, that is the way how a bucket-chain will be working.

So, you have seen, there is a crawler mounted and there is a pad mounted or walking mechanism as well as you have got a rail mounted mechanism. So, you can see this figure how the rail mounted mechanism it can travel. It is travelling speed will be very very slow because it is a very heavy machine. Now, while traveling there is your ladder that on which these buckets are mounted is kept in front and it can move in this way.

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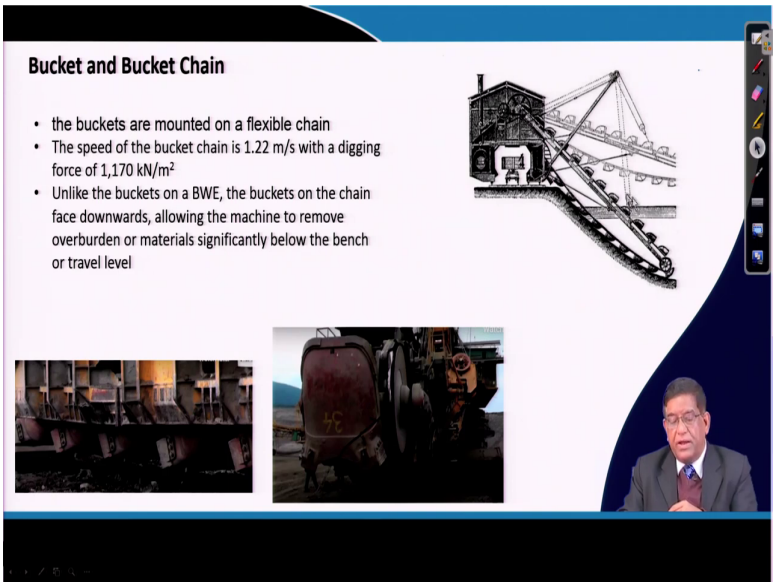

So, now in this figure you can clearly see how the buckets are mounted on the ladder? You can see here is a sprocket, on this sprocket there is this chain and on the chain this bucket is mounted. So, you can see that how the bucket and the bucket chain works? It is the old model where you can very clearly see when the machine was first developing in the last century.

In the last century, machines were very simple all are mechanical and electrical not much control and not much that, the design features were also very simple. But, you can see here

that is with a drive this is the chain is moving along it and the bucket is taking the material and then it is loading onto this conveyor belt or it can be that trolley or railway, rail wagons are kept over here that can be loaded and do it.

So, if you see the bucket shape, you can see over here the buckets will be having the teeth depending on the material, which you are cutting that this lip portion of the bucket and the teeth and whether there will be a teeth on the side or not this will be depending totally on the geo mining conditions. And, you can see here that chain links that is on the sprocket they will get engaged and the, they will be running.

Now, here the drive is given at the top here. So, that means, this is an idler sprocket. It is because this sprocket is a driven sprocket and then the chain is moving in these directions. So, you can see here while cutting how the bucket is moving it is moving in these directions. So, it is a the chain when we say it is a flexible chain means there is a chain as you have seen ordinary chain with a link and then it speed is given 1.22 meter per second. And, the digging force it is coming 1.170 kilo Newton per meter square.

So, that means, it cannot cut very high compressive strength rock it can cut only lose one. So, there is only 1.1 mega Pascal's, 1.2 that is a very loose material. Now, unlike the bucket wheel excavators the buckets on the chain face downwards. You can see here this is exactly face downwards. Bucket wheel excavator bucket will be in the opposite directions ok. Now, this is also operating below the mounting or the below it is standing position that is the difference you should note it down.

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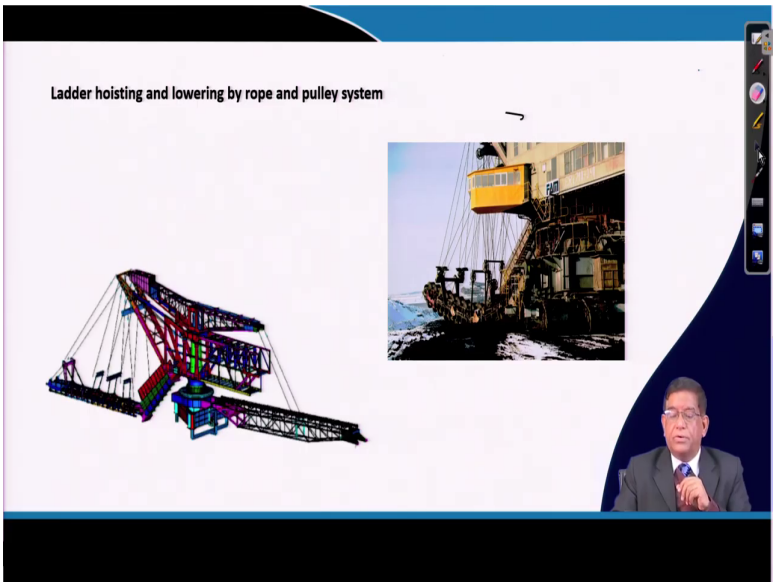

Now, you can see the hoisting mechanism. In bucket wheel excavator you have seen there are only two ropes are hoisting it over here. But, here as because it will be having a load and with the whole boom you can have a different type of hoisting mechanisms at different points it is supported.

Sometimes they say your whole it is supported over here and the main control is from this so that your hoist winch will be supporting. Similarly your discharge boom, discharge boom is also can be hoisted and lowered with the help of a hoist winch. So, these are the systems, which is available in bucket chain excavator.

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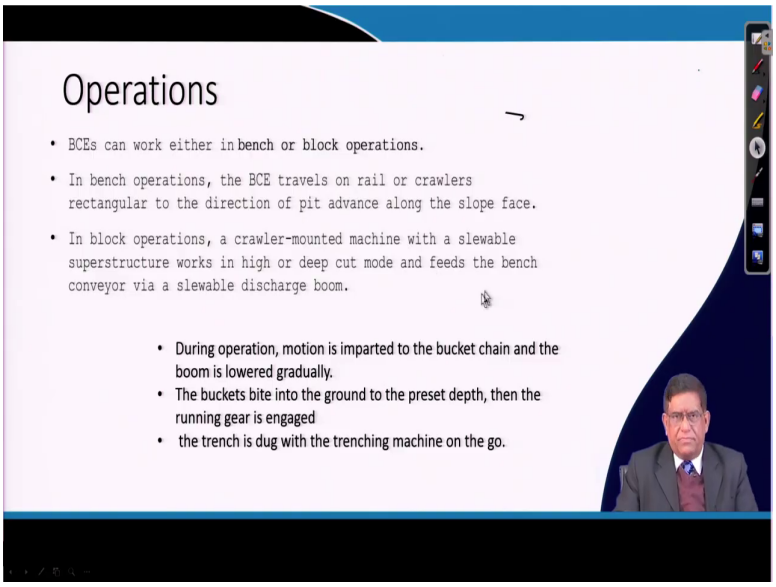

So, coming to other how it operates- it work either in bench or in a block operations. In bench operations, the bucket-chain excavator travels on rail or crawlers and in a rectangular directions and the pit advance along the slope of the face as we have discussed earlier.

And, in block operations, the crawler-mounted or the slewable machines it can be a working pit or a crawler mounted. So, that is where how that means, rail mounted machines are working in the in your rectangular and then this can be having and then there is a more flexibility in other.

So, during the operation, it is motion is important to the bucket chain and the boom is lowered gradually. You lowered it gradually, then is your bucket chain will start moving. The buckets bite into the ground to give a preset depth that how much it will be cut depending on

the that cutting force and depending on the rock type. You decide that how much will be the bite, so that the bucket can be filled.

Because if you give a high bite; that means, if you lower it more then what may happen that is bucket will get stalled or the bucket chain drive it will be overloaded and it may trip. So, those type of problems operational problem may come. That is trench is dug with the trenching machines on the go. This can be used as a trench cutter just like your some of this backhoe making small trench this bucket chain excavator can also do a very good trench cutting.

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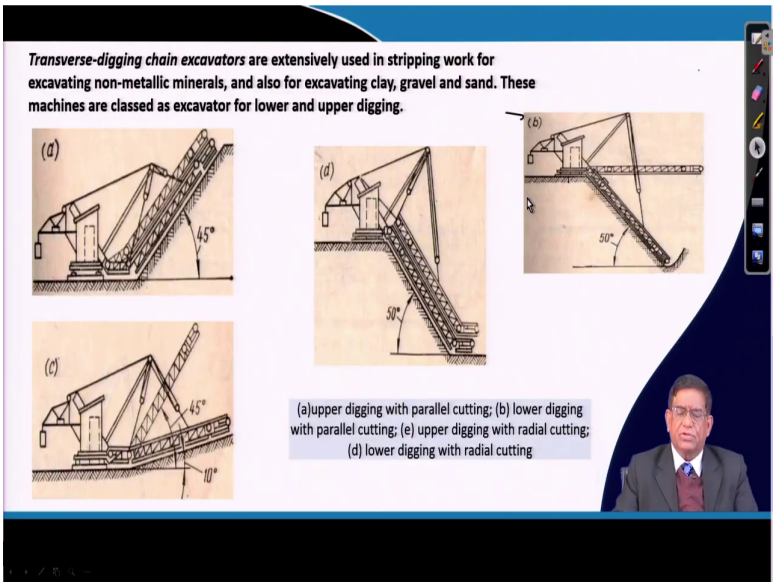

So, you can see here that is the how transverse digging chain excavators are extensively used for stripping work and excavating non-metallic minerals and also excavating clay, gravel and sand. These machines are classed of excavator or for lower and upper digging. You can do

this example your bucket chain excavator is also used for scrapping down the material from a slope.

So, that means, you can make a special arrangement that is there is a bucket-chain buckets are there. So, it is cutting down and then you can have the material you can put it over here so that is a scraping down this type of high digging is also possible, but normal operation is always a deep digging. So, these are also sometimes that similar arrangement is done in some of the reclaimer, that is your scrapper reclaimer there you can use this similar machines.

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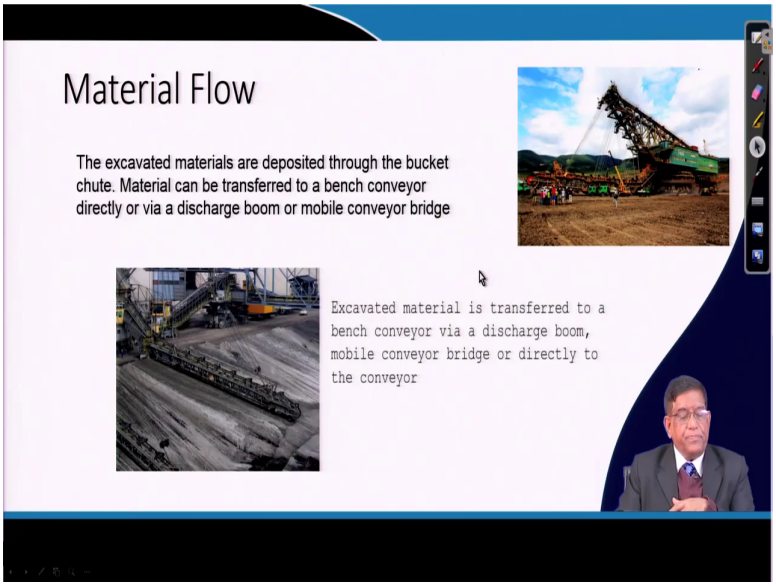

So, as you can see here the material flow from the from this slope the material is cut, then it is given because it is a slewable discharge boom is slewed down and it is maintaining this angle here. The material is transferred from this to this conveyor belt and then this is giving to the, this length conveyor belt and this taking the material away.

So, your design of this face on which you will be working there it is important that how you will be organizing your work, so that the material flow with a minimum distance travel it can go to the destinations. Now, there is a normally that is your the bench conveyor or we can say that is also a shiftable conveyor as this face moves that conveyor belt will have to be shifted.

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So, you can also use these machines as a cross pit. You can see here that is, this is your overburden below that the lignite is there. So, what it is done, these machines will be moving in this rails over here so that it is cutting a there is a rectangular block is being cut, the material is transferred to this conveyor belt and then this conveyor belt is giving it to a spreader system and the material is spread over here.

By that it can 100 – 200 meter span you can transfer the material. So, this shows that exactly you need to engineer or think depending such type of deposit if it is available it may be a

horizontal flat deposits with an uniform overburden over there and the stride length is straight, and you can easily develop a design a surface mine, which that is your rectangular face block.

You can cut the rectangular block by this ones and you have got this the ground is properly suitable for mounting this rail, you can do it these type of arrangements are there.

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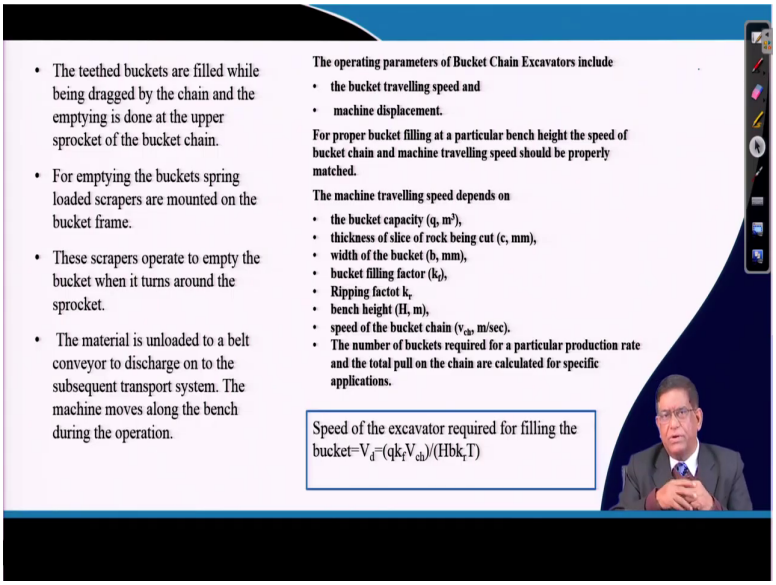

So, these teethed buckets are filled with while dragged. So, that is the main operation is the bucket is filled during the dragging over here by dragging operation is done by the chain. And, then the for emptying the bucket that is bucket will be emptied at the end by your spring loaded scrapers also can be mounted within the bucket frame so that when it is there it is going to the dishes positions you can scrap the material out.

That type of devices can be provided in the machine. And, that this is a that scrapping mechanisms, it is a option if the material is very sticky and there you may have this type. Otherwise, the bucket if you can make this move in such a way that while it is going down, it will be free flowing material will get automatically discharged. And that material will be discharged on to the, that is your belt conveyor.

Now, the most important thing is the capacity or that it is how much this material will be working that will be producing will be depending on the main operating parameters, which is the what is it is travelling speed of the bucket and the machine displacement at what speed it will be moving from one place to the another because these two motions will be determining the bucket capacity.

So, the main parameters affecting is that what is the particular capacity of the bucket, what is the thickness of the slice it is cutting, then what is the width of the bucket lip and then the what is the bucket fill factor; bucket fill factor means the bucket may be having a capacity say 500 liter, but when you are exactly filling all the 500 liter will not be filled.

As I told you in earlier there is a two type of capacity – stuck capacity and heap capacity of the bucket. Normally, this 500 liter is just stuck capacity given, but the whole thing will not be coming up in while working in depending on the orientations of the, that your boom.

And, depending on the material property you may get 70 percent, 80 percent or 95 percent of this bucket fill that is a bucket fill factor. The ripping factor it depends on that exactly what is the characteristics of that mass which you are being cutting, is it is ill repayable or that repayability of the material it is also affecting particularly when you are using it for hard-rock excavations.

Then what is the bench height and the speed of the bucket chain – this makes the total number of buckets required for particular this particular production rate can be also calculated. So, the speed is calculated by these equations please note it down, that is, all these parameters when

they put it you can easily calculate the speed required for a particular move. So, you will have to do such type of problems over here.

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As compared to the previous machines used in Bulgaria the same Takaraf company they have used the machine for coal mining in hard coal mining in Russia and there you can see the difference. There it was 1,350 liter, but here it is a 1,400 liter. There you could see that 11.5 meter that was the that your boom length, but here that boom length is also much longer that is your that discharge boom is here it is 35 meter there it was only 22 or 24 meter.

So, that is why you can see the discharge rate is of course, here it is less depending on the, because the cutting resistances are more the number of bucket discharge will be less. Though it has got a it has a capability of the speed is 1.22 there it was 1.17 meter per second.

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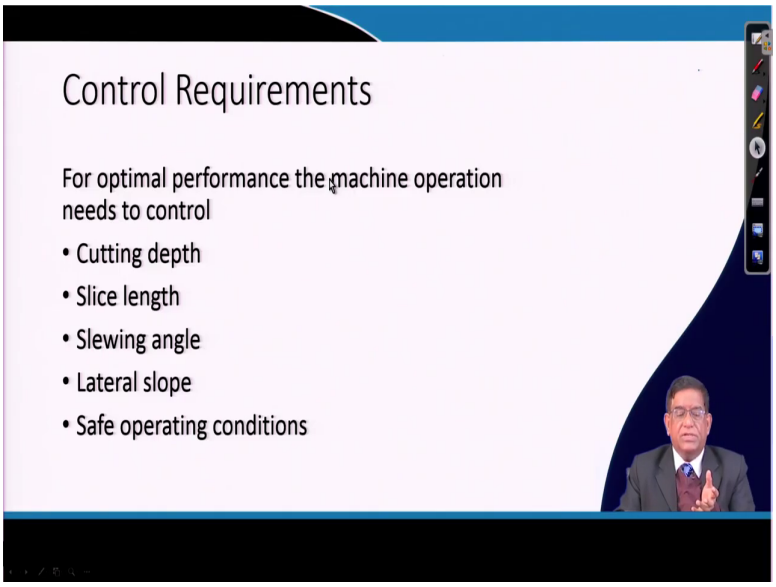

So, that means, depending on the site conditions you will have to do it. Now, while operating you can have instrumented control that is nowadays everywhere mechatronics applications are there, you can have the proper control mechanism for cutting depth slice length, slewing angle, lateral slope and then any safety warning under that conditions it will be given and you can move it.

So, this is where you can start up your study that if such a machine is there, you can what type of control mechanisms you can develop, what type of data and information's you will be collecting. And then how you will create a operation, operators cabin, you should have a display panel where all the operating parameters will be collected and then sufficient warning will be given if the machine is not going to work well.

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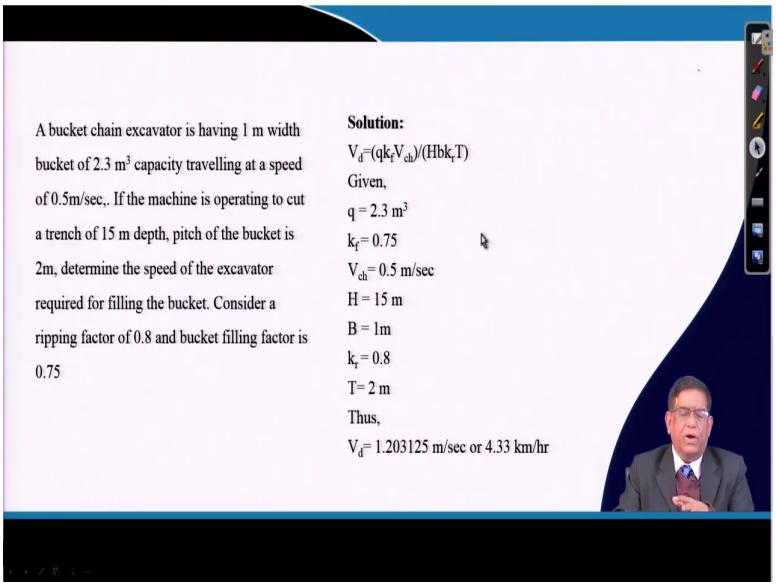

So, just you note down this particular problem if you can calculate out with the equations given you before just now. A bucket chain excavator is having 1 meter width bucket with 2.3 meter cube capacity traveling at a speed of 0.5 meter per second. If the machine is operating to cut a trench of 15 meter depth, pitch of the bucket is 2 meter; distance between two buckets, determine the speed of the excavator required for filling the bucket.

So, that at what speed it will be moving, considering the ripping factor of 0.8 and bucket fill factor of 0.75 given. So, that same equations which has been given over there. You can derive these equations try to it put some more conditions, try to find out what are the things and then you can find out if that productivity will have to be improved, which parameter is a more.

So, you can do a sensitivity analysis that is what is called exactly if you can find out the capacity hourly production capacity is calculated out, then you have identified different

parameters. Now, which parameter affect more keeping all the things same if you draw a graph by wearing one or two parameters, then you can see that where exactly which particular parameter is affecting the productivity most, that is called a sensitivity analysis.

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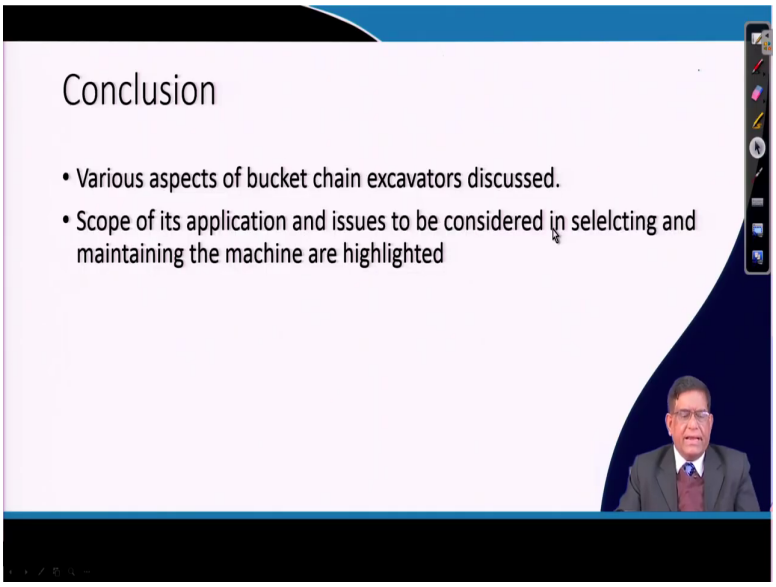

So, you could you should start, take up a small work that is how will you do, determine that the productivity or capacity of these machines depends on what. So, we have discussed this machine with various aspects, your merits and demerits compared to the bucket wheel excavator you can find it out because of its applications.

And, that you study there are many good research articles are there; also in the website number of materials are available. Please study it and after this we will be discussing the other continuous Mining Machinery.

Thank you very much.