Mining Machinery
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Module – 05
Lecture – 19
Surface Mining Machinery: Machinery for Cyclic Excavation: Hydraulic Excavators and Back Hoe

Welcome back in our discussions on Surface Mining Machinery that we have been talking about this Machinery for Cyclic Excavation. We have introduced you what is electric rope shovel and today we will be discussing on Hydraulic Excavators and Back Hoe. These are the main working force or the primary surface mining machinery today being used.

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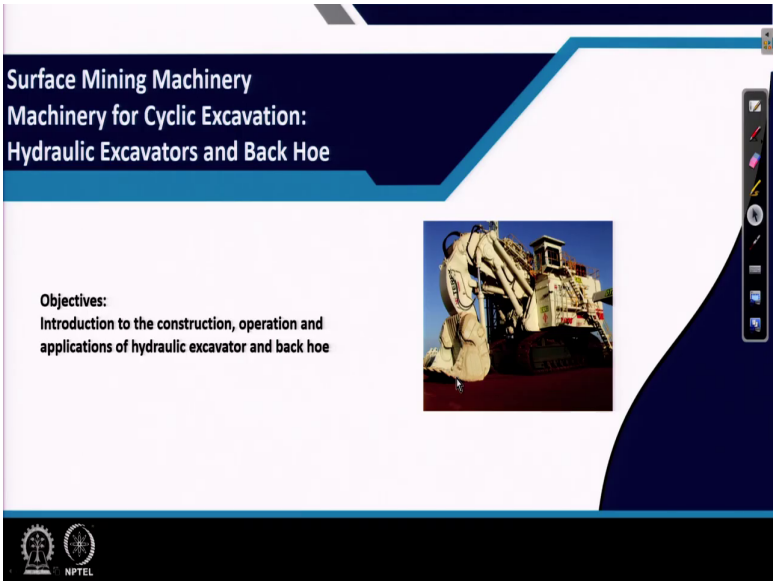

In the photograph here you are seeing the world's largest hydraulic excavator that is giant under a gigantic machine which is being used in surface mining, because you know that modern surface mining are for all high capacity. So, there very large capacity machineries are deployed. So, you will be learning about this big machines about their construction operation and a little bit about maintenance.

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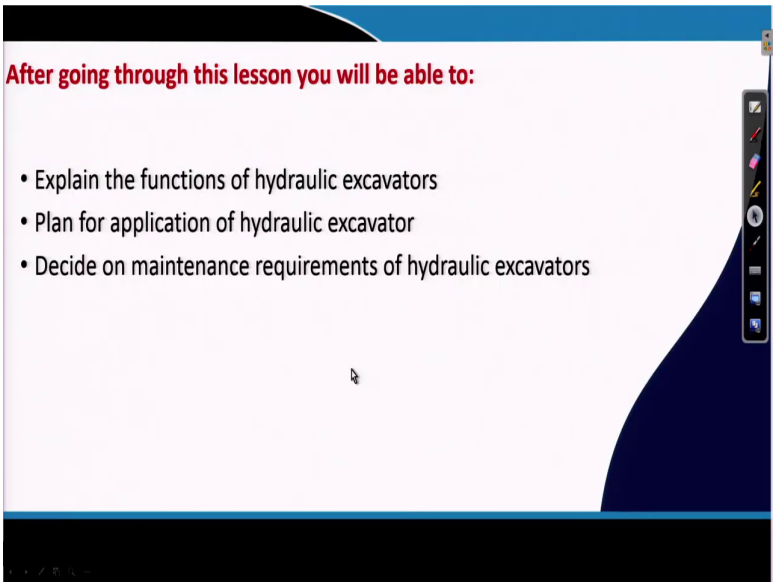

So, that after this class you should be able to explain the functions of hydraulic excavators, what are the work it does, then you should be able to plan for application of hydraulic excavators. If given a mining situation you should be able to decide on that what type of and which type of hydraulic excavators you will need to use. And also you will have to be able to plan that in how you will be investing for maintenance of these machines in the field.

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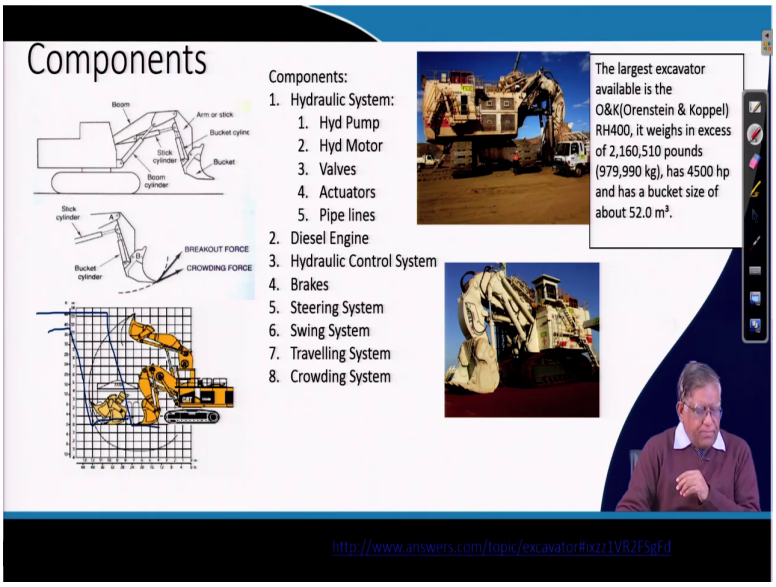

So, let us talk about that this machine as you have seen the world's largest excavator which is a O and K Orenstein, this O and K originally made this machine and it is having total weight of more than 1000 ton such a huge machine which has got this bucket with a capacity of 52 meter cube.

You can imagine how big this is now such a big machines to work there are main components you can see here schematically that how that machine this big machine or this machine is basically what. It is basically you are having a bucket here just schematically it is shown as a bucket, this bucket is operated by a bucket cylinder and there these cylinders is also there is a arm or the stick the movement of this stick is done by the stick cylinder and then there is a boom that boom is moved by a boom cylinder.

So, basically this front part which you are seeing this has got a bucket cylinder, this is stick cylinder and the boom cylinder. So, by this the front attachment of this main your that this undercarriage and there is the super structure which is exactly mounted on a turntable which can give a swinging operation.

Now, as you can see you will have to try to draw you should be able to while we are discussing the functions of this machine, this particular drawing should be very it should be at your hand you practice this just start with giving this line first that then you draw this part, then you give this connecting cylinders then you draw the bucket and then you draw this it is in this sequence if you draw it will not take more than 1 minute to draw such a figure.

Now, why this is here the beauty of this big machine is it has got a wristing action; that means, the front bucket it is just like our wrist it can give a wristing motion which the electric rope shovel bucket cannot give. Now when you give this wristing that is why it is getting another force which is called your breakout force. In case of your electric rope shovel you are giving this crowding actions when you are pushing this to that, but after that you are just hoisting.

But here you can push then by giving this wristing action you can properly fill the bucket that is what is a beauty of this machine and you can see that this diagram which you will find always with the manufacturer leaflet.

It gives this your the zone in which the bucket will be moving or this is the area in which this bucket can work in a designing of this machine and also your designing your face you can take care of that where the bench should be there and how the bench should be oriented. So, that you can use this machine.

So, while deciding for a particular application and then for a particular mine you need to see whether that is exactly if your that bench which you will be creating over here this bench whether you will want to work this bench or you want to work say here if you want to want to

work a this type of bench. That means, which will be the range of its working that can be decided with the help of this diagram which are available with the your manufacturer leaflet.

So, now you must know that what are these components, as we said earlier every machine has got some functional element and there are some power source and there are some control elements. Now the here this machine is basically the whole operation is done by a hydraulically.

You can see there that the machine will be having an engine and that engine will be running number of pumps, that which this pump will be pumping the fluid or giving the pressures the generating pressures on the fluid which will be working different actuators.

So, basically this machine is having the main power source as an engine which can be a diesel engine or can be an electric motor, from there it will be working this hydraulic system where we will be having different type of pumps. There will be hydraulic motor valve actuator and pipeline, this comprises the hydraulic system.

Then there is a hydraulic control system is there by which that is exactly you will be having a joystick type of operations you will be controlling the different valves and then different circuit will get fulfilled, which you have studied in your hydraulics introductions we have talked about.

Now, by that for running of the machines what we will have to have you will have to have a brake, that whenever any machine is there whether you are swinging the machine that time you want to apply a brake. Suppose a big rock is coming you do not want to go in that directions you should brake and then you can reverse, those type of control systems are there for that. There is a steering system as you can see this machine is a crawler mounted machine.

So, whatever we have talked about that steering of a dozer that steering of your electric rope shovel, here also you can change the directions while it is moving you can control the speed of one and you can give a turning to the machine. Similarly it has got a swinging system that

is your hydraulic circuit is arranged in such a way that the swing motor will be rotating and you can make this machine to move about an axis.

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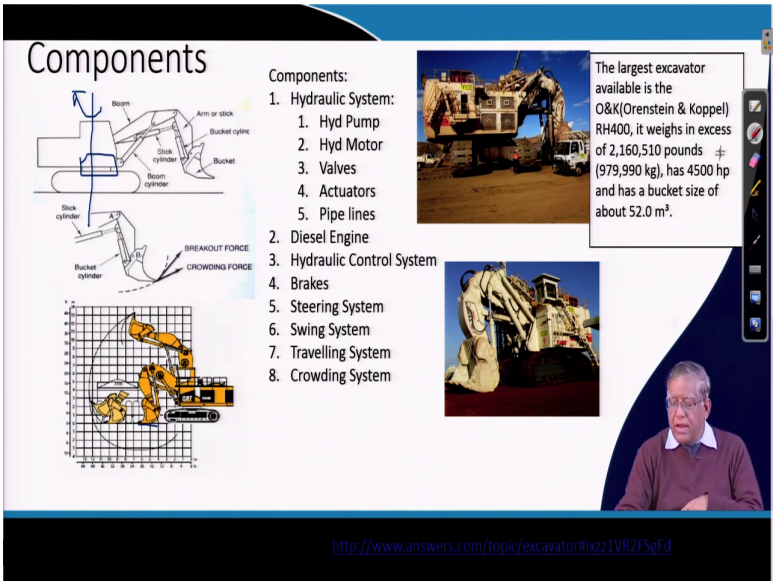

So, that is exactly about this axis this machine can give a swinging motion or rotations. So, for that this portion is the turntable where we will be having a sun gear and then your this upper portion it can move over here. So, this is your undercarriage this superstructures can swing above that machine.

So now, you understand this there is a crowding system, means how you will be pushing this; that means, by movement of this arm or arm stick and the bucket, you can give a motion push motion of the bucket towards the material you are collecting. So, this is what a hydraulic excavator is.

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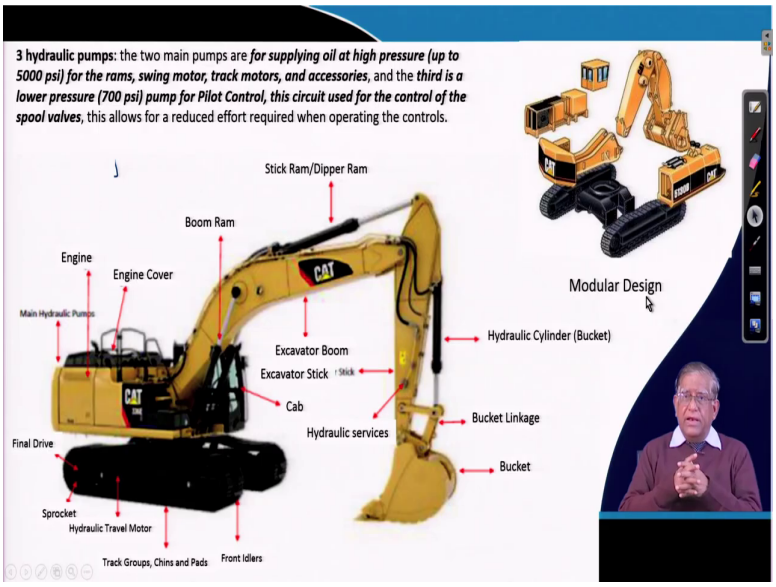

So, now this you see little bit more about this machine, these machines will be having as I said the engine will be running mainly 3 pumps, that this pump for supplying the oil at a high pressure that will it will go up to 5000 psi that pressure and there will be the that mainly the swing motor for swinging operation track motor for the for movement and then there are number of accessory motions which is there that is given by that pump.

And there is some low pressure pump is there for the control circuits and all for just joystick movement for the brake movement there you do not require a very high pressure pump, so there is a separate pump for that. As you can understand depending on the weight of the machine when you have to move over there really very high energy is required for that to give the momentum to this.

So, now if you see once again that you have seen the components you just again recapitulate what you have learned in the previous slide, I told you about the bucket. Now there is a to get the wristing operation of this bucket we have got a link mechanism here. So that means, by motion of this your this link will be here there is a you can see the three bar link here, then if you have studied in your mechanics that how different exactly the motion of this tip.

This tip will be following what locus that can be determined by this if this is the your pivot point here by movement of this links can give different locus of this tit or the front part of it. So, this is how it is controlled with this hydraulic cylinder.

Now here we are seeing again stick ram or dipper ram, that is exactly ram is when your this your piston is about more than one half time that your cylinder head that is a that hydraulic actuators this is sometimes it is called as a arm cylinder or it is sometime called a stick ram. Or there is a boom ram that is your boom cylinders in sometimes you say here this port part is called your boom and this is often referred to as a gooseneck.

You can see here it is just like a gooseneck, because the goose has got this beautiful motion and movement and that from the nature has been designed over here and incorporated. Now this your excavator this stick you can see this is called the stick or arm, then you have got the cabin located over here which is ergonomically designed engine is given over here and their main hydraulic pump is or hydraulic power pack is here.

And then there is the from there this crawler is driven for the crawler final drive is coming to the sprocket over here, this sprocket is rotated. So, that is exactly the rear sprocket is driven, the front sprocket is idler because of this rotation this chain will be making it to rotate it over here. So, that your this hydraulic travel motor is located over here from there the power is coming to the sprocket and it is done.

So, all these components are available the manufacture, manufacture it as a modular design. Normally 8 parts these things will be designed and transported to your site and in the site if you procure a the hydraulic excavator you will have to get in your mine a particular place

earmarked for erection yard, there it does machine these components will be coming you will have to put it over there then you assemble it then you run it over there. So, this is the way how the operations are carried out.

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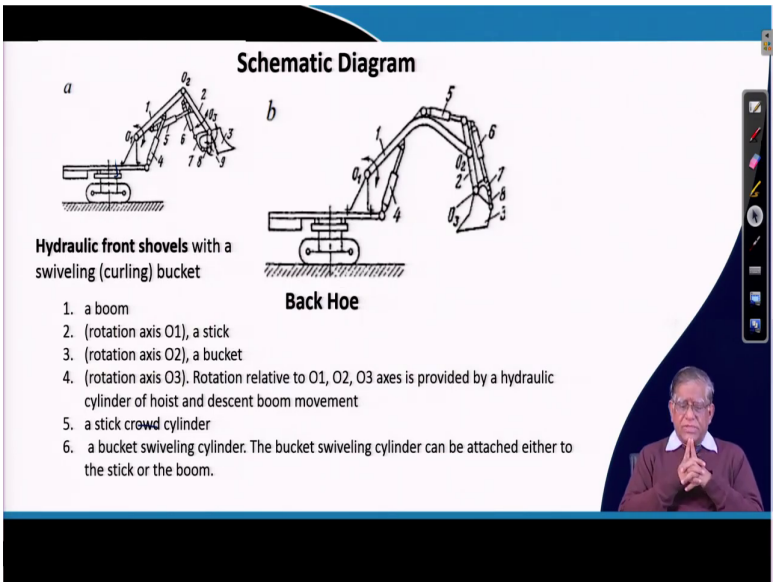

Now, coming to the schematic diagram of the figure which you have seen, you can see here where is the rotation taking place. So, this diagram here I am introducing to you this back hoe. Now you have seen the previous diagram this is a back hoe and then this was in excavator; that means, how the bucket is working over here it is giving a forward and then this is the other bucket is giving a backward.

So, this is when it is cutting back it is called your back hoe and the other one is front, that is your shovel. Now in this is the front shovel and this is your back hoe. Now for both the

operations only the portions how the bucket is fitted and the design of the bucket is different rest of the things are similar.

Now, what is here mainly there is a where the rotation is taking place, so that means while designing the machine you will have to get this pivot point about which this motion is there. You can see the boom is moving about this one this is the axis on which it is moving. So, your movement is in the vertical axis, so that means there will be a point on which it will be moving like this.

So, this point how you will be the load will be transferred to this point and what type of system or component will have to be there, so that under that load with there is no much wear and tear of this and it can survive better. So, this is the very critical point where it is moving. Similarly the front arm that is this arm it is exactly moving against this O 2 or in case of here this is the O 2 about which this arm is moving, so then the other that your bucket is moving about this point.

So, you can see here the differences here we are having a gooseneck here we are having a boom which is a straight. So, depending on the design it will be changing. So, mainly now have you understood now there what are the different type of powered motions are there in this machines. If you see that wherever this rotation symbol is shown that these are the powered motions, other powered motion is your this crawler will be moving that is your powered motion and then this will be swinging.

So, you can see that you can make a list of the powered motions or the powered functions and for that those components will have to be designed in such a way that the what will be the power requirement that can be calculated and your total use of energy in this machine can be optimized, when your these components are designed based on their function and then that is where the main analysis work are done.

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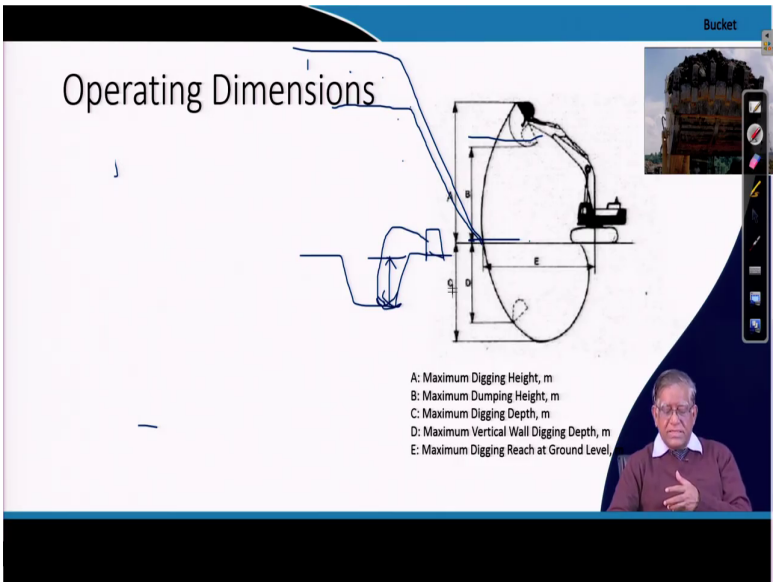

So, you can find out here this operating dimensions this is important, as I was telling you that your depending on the that your working site you will have to make this select which machines will be useful for you. Now that machine has got certain operating dimensions, you must know about that what is the digging height; that means, it cannot dig a face that is your this slope or that as your working face cannot be like this.

It is a maximum it can if this is a slope angle you are doing you will be having here. So, up to here it can cut to certain extents, but there is a restrictions here; that means, your this machines will have to be located over here then only your this distance you will be able to reach it over here. So, that is why that what is the maximum height it can cut will be depending on what is the maximum digging height it has got.

Now sometimes of course, depending on the soil type if you can cut it over here sometime if this is loose material it will automatically come down and you can negotiate that is the operational things depending on the site. But you need to know that the machine by design how much maximum digging height is given and what is maximum dumping height; that means, you will be loading it onto a dump truck.

Now, while loading onto the dump truck you will have to see that this dumping height that is the lower point that is your dump truck, if the height is going up to here this will get touching and there will be a bang on the dumper.

So, that is why the dumpers should not be having it is height more than this dumping height of the shovel. So, that way in your real applications you will have to make your dumper compatible with the machine. So, that is why the machine parameters are important that other thing is the maximum digging depth.

So, while standing over here how much you can dig. Suppose you want to make a trench like this your machine is sitting over here. So, by seating this machine over here you can do a cutting over from here, so this means you can make a this type of depth of cut you can make. So, this is possible when this you know that what is the digging depth.

So, if for a particular area you need to get a digging depth of say 5 meter there you will have to see that while selecting the shovel you specify that this is my operational requirement. So, the other one is your digging reach that is your what is the reach of that up to where it can cut.

So that means, while this is standing on a particular position from there the center point up to where the bucket can come, this is exactly that by operation of this different cylinders what is the optimal radius you can get; because this distance E can be a function of the motion of these cylinders.

These 3 cylinder there they will be determining this E, you can make a simple equations to find out and that what is E and for if you are given the range of movement how many meters each of them can be moving, then you can find out how with them we can get E.

Or that means to get this E how much of this cylinder will have to be operating, how much this cylinder will be operating and how much this cylinder this they will be exactly making over there. Those simple mechanics and then little bit of that your mathematical expressions you can derive.

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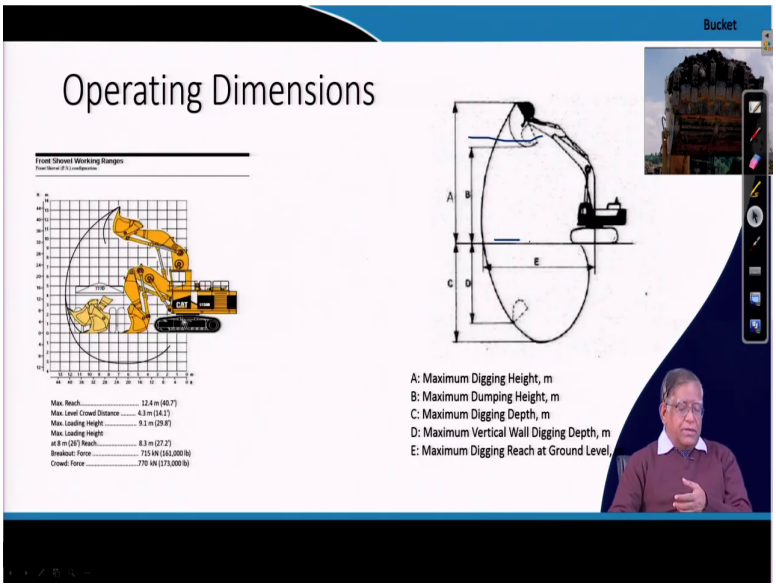

Now, coming to these machines, now these dimensions are put it in this then you can find out exactly how much material it can excavate. You know that this is the potential by sitting in one position how much this area can be cut or that means, then you can see that if you know

that area you know the bucket lip bucket width, then this much volume of material can be cut by sitting in one position.

Or and now you can sewing it by giving it the next cut by sleeving the machine then you can find out that how much it can cut. So, like that you can find out that how the design of the face will be there and how ultimately the mine will be looking like. So, this is where the machine operating dimensions are important. This vary machine to machine it is say in a particular machines of caterpillar, this is giving as a you can see get yourself familiarized with the type of information you get the operation manual.

So, here I ask you to do 1 exercise find out that who are the different manufacturers of hydraulic excavator, like you may find out nowadays lot of acquisition and merging is there one company by other company and their machines become their machines like that.

But thing is that the major designer like Liebherr O and K P and H Kamacho Hitachi all these are there. So, these machines manufacturer website you go and there you download the leaflets and from there you find out and then you know that at present what is the range of operating equipment available make a tabular form get an information's fill the machines from those information.

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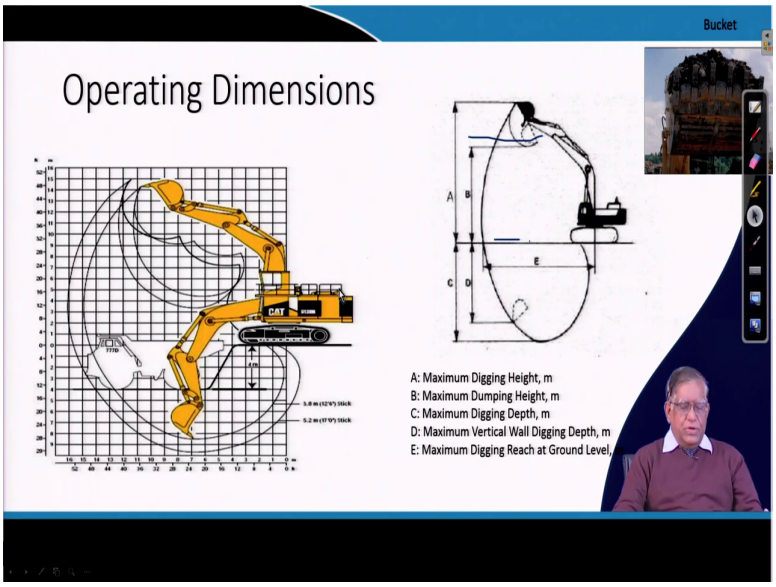

So, you can see that the operating dimensions in a back hoe, your this back hoe by you can see here by controlling these pistons it is either this can be placed over here or it can be placed over here. Now while it is placing like that it is cutting the material and then it is loading. So, how this machine operates in fill you can understand from here and then you can find out the 3 dimensionally how much material it will be taking and then while taking it over there and then positioning the dumper.

This motion total distance of movement total coverage of movement that is related with the number of that is how many seconds a particular motor will have to operate and how many seconds that how the fluid will be under pressurized conditions and how much energy will be required. Those type of analysis exactly gives you a confidence and how you can improve the operation of the machines, how you can exactly design optimal phase.

So, when you go to the field you see the machine is being operating and a particular phase of the mining phase has been created. There is always a question is that phase an optimal that will be depending on what is the rock properties, what is the fissures and all whether you can loosen instead of raising up to the top.

You can just leave the first 1 meter you can take it out over there that will automatically slide down, if that that thing is coming then why should we come up to collecting the top of it. Because even every 1 meter of or 1 centimeter of movement is a you are using the power.

So by that when you are getting it like that you are not raising up to the total bench height, because the top portion will slide down at that time what you are doing exactly you are reducing the cycle time of the machine. So, like that the productivity can be enhanced. So, those type of analysis you will be doing, but before that try to understand that how this machine is.

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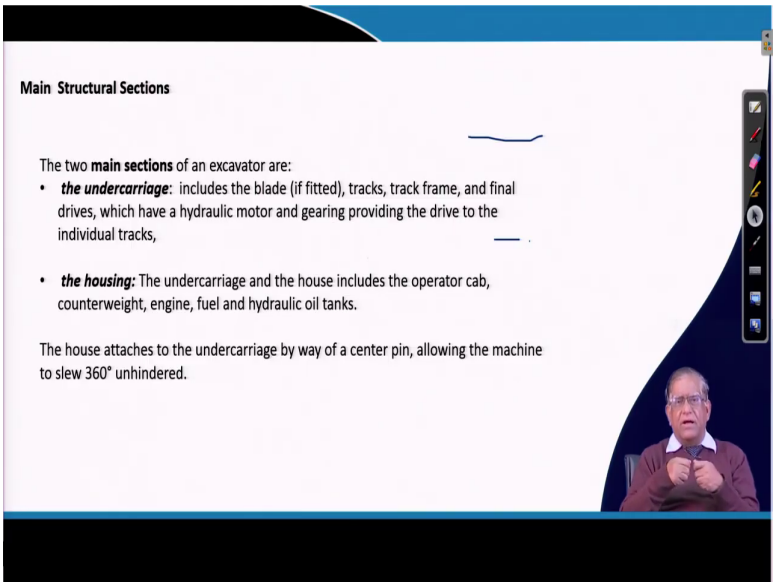

So, that machines has got some structural component, as I said already what are those are undercarriage and the housing the lower portion and the upper portion. And the housing it has got the front that is a pivot point I have said on which your front attachments are collected.

Now that front attachments which you have seen which may be having arm stick and the bucket or we may having a boom that is a gooseneck boom or a straight boom with that. That front attachments can be managing it is exactly when you have seen that whether you are using a rock breaker you can make a reaper you can make a front end loader anything can be brought over the other prime.

Sometimes it is possible that in the mines you do not buy all these machines, because sometimes a same machine that in instead of having 1 rock breaker and 1 this one. Sometimes one you write the superstructure and undercarriage you create and then the front attachment

can be changed after the blasting, you find that there are lot of big boulders have come you can use that remove the front attachment bring a breaker you break the things.

And then you collect you connect the front attachment with a loader you can load the things over there or there is a if the necessity of to make it an excavator you can make an excavator. We will be learning about what is the difference of an excavator and loader later on.

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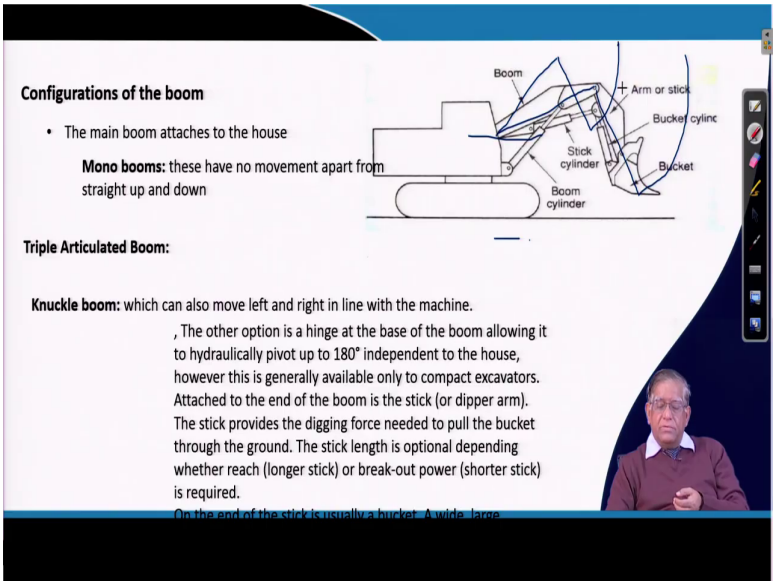

Now this what is the most important thing I told you about the dimensions is how you configure the boom. Configuring the boom means exactly controlling that your working envelope, what you have seen in the manufacturer leaflet it gives an that is your working envelope.

Now, that working envelope can be controlled by configuring the boom with its different attachments. So, that is why there all the parts are articulated it can be separately controlled, your movement you can keep this is fixed. If you are keeping this portion fixed and then you are having this only then your movement will be only a arc like this.

Now, if this point you raise these things that is your this point, if you are keeping it the boom is now raised then your this arm will be having a working envelope here. So that means, working envelope can be from this position to this positions and during this you can do the cutting of it. So now you have understood this basic operation different type of booms different type of sticks are available you will have to study about this.

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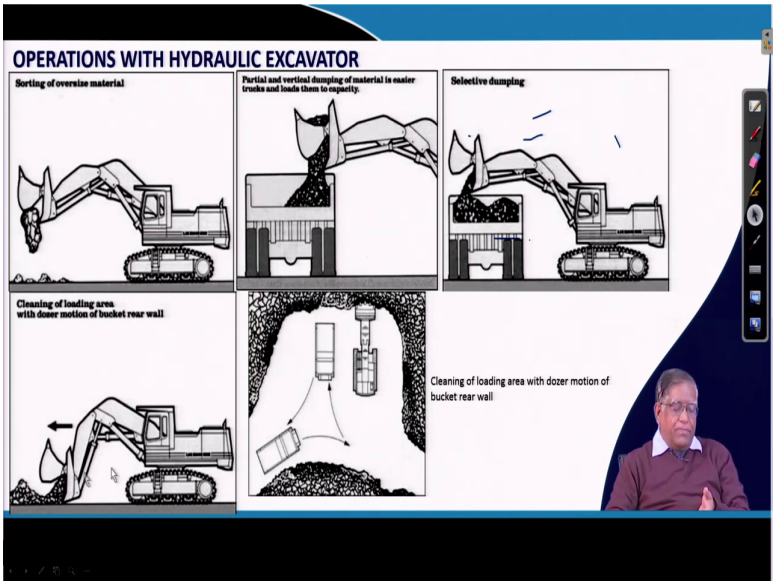

Now, that in the operations you can find that this it can load on the dumper, it can sometimes handle a big boulder. Because, here the bucket is open or operated by just having your one

you are having an unloading of the bucket by motion of this backside this material is loaded over here. So, you can separate out a big boulder and do not load it on there. So, that the crusher will be overloaded or you can separate this type of selective operations can be done you can load the truck uniformly.

So, that wherever it goes because you by you have got the control on the extending this in electric rope shovel it will be just dumping as a it will develop as a one cone and then it is coming. But here you can spread uniformly the material over there. Then while that this exactly loading in the fill you can clean this, sometimes this front excavators it can also work as a just dozer you can dress your face your that cleaning of the face to make it properly collected this type of operations can be done.

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So, this back hoe operation is a very very important thing, you know one thing the back hoe is working by sitting over the bench and the excavator if this bucket was not a back hoe bucket if it was an excavator [FL] this side bucket then your the machine would have been sitting over here; that means, the dumper and the machines will be at the same level. But as it is a back hoe it can exactly dig from the bottom and it can load like this. So, this diagram explains how a mining back hoe works.

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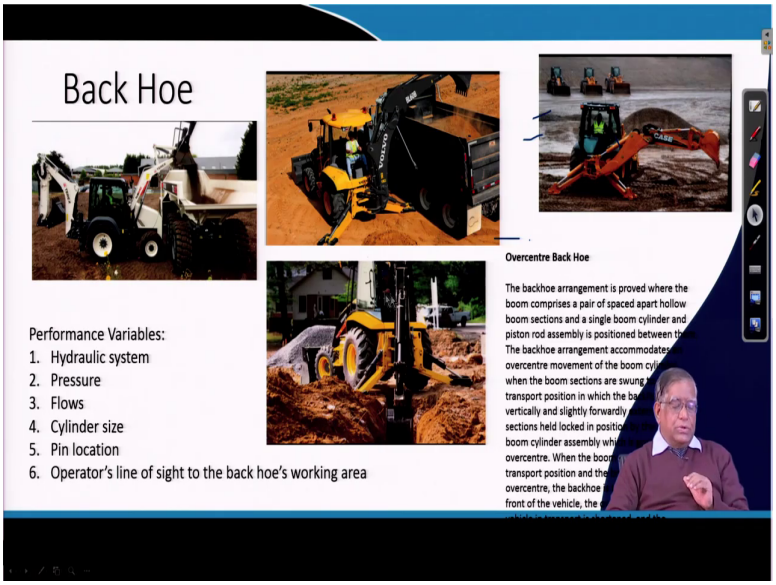

So, you can see here that in a back hoe also. What are the things that as a system variables, which you can study control and design and develop your performance. So, there is a; there is a hydraulic system pressure flow cylinder size pin. Now you can see one thing this operation of the that front attachments or the excavator you can see here the background the tractor part

is same here is a front end loader collecting over there at the back side you are bringing an attachments.

This attachment you can see from here that is a back hoe has a attachment it is fixed over here, it has got a separate mounting you put it over there and then as because it can swing a particular range you can work over there.

So that means, you are having the other machine in which you change a front end and you can do the back hoe excavation purpose, if you want to draw cut a trench like this is there. So, this is a over center back hoe it is said this is the modern development only last 5 10 years such type of machines such type of modularity has come because of the economic uses.

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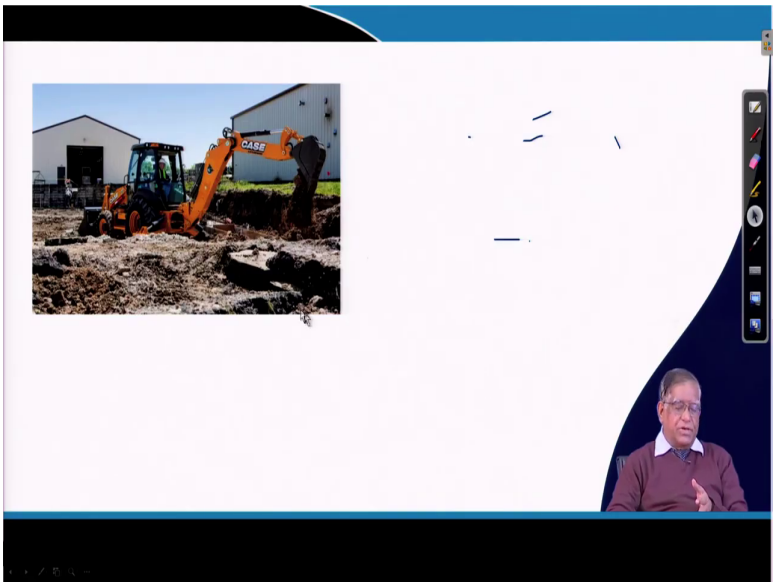

So, you can see here the machine backside is a different machines; but only the front attachment is corrected for making a back hoe operation you can do the excavations and do the work.

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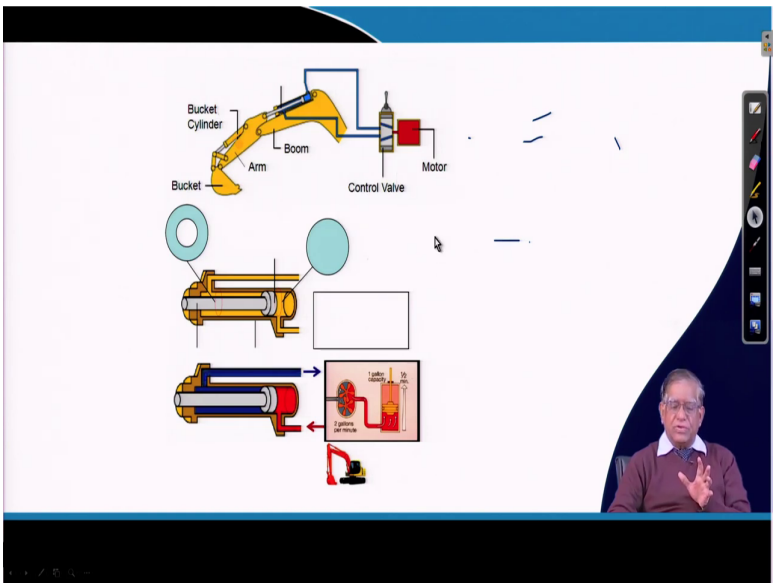

So, case is a company which make this type of things. Now if you see here the how the hydraulic system work over there from the motor you are running and that the pump is getting to the fluid you are controlling which is joystick, you are giving the pressurized fluid to the different cylinders.

So, mainly these hoes pipes which is bringing they will giving the control. So, main operating component of this machine is that pump, that hydraulic pump we told you about that gear

pump and vane pump which is to be there to get the pressurized fluid and the piston operations will be there.

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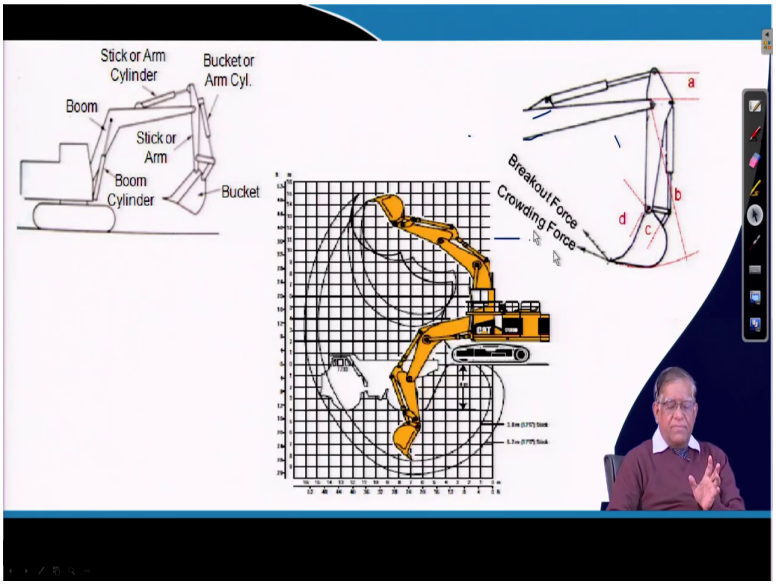

So, such type of things are available as we recapitulate again that what are the main component your that how this will be operating over here. Now if this bucket is to move you can analyze that is how much braking force will be coming, depending on how much force are coming at this point. So, it is just a draw a free body diagram and then you find out and calculate how much force will be coming over here.

So, this is an exercise you please try that what is how will you express this breakout force in terms of this different forces at that pistons and then on the how this will be different, if the dimensions of this machines are different. So, this type of exercise you can do.

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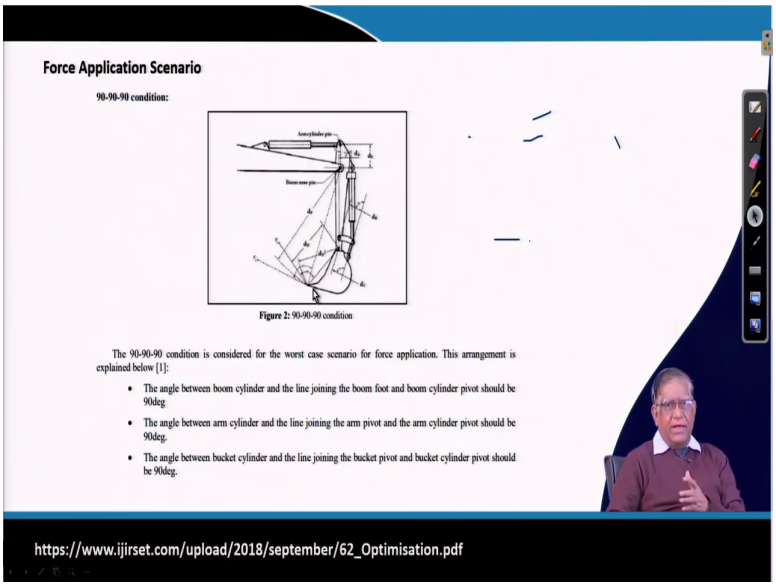

And then the different force application scenario; that means the worst condition that is highest force which will be coming over there the maximum stress will be coming on to this when this is a 90 degree 90 degree 90 degree conditions.

So, this what is that exactly in this machine in this machines when I say that the front attachment configurations can be changed you take out different possibilities and under different possibilities you find out how much force is coming over there or how much stress is developed and that is the way how that exactly an excavator operation is analyzed.

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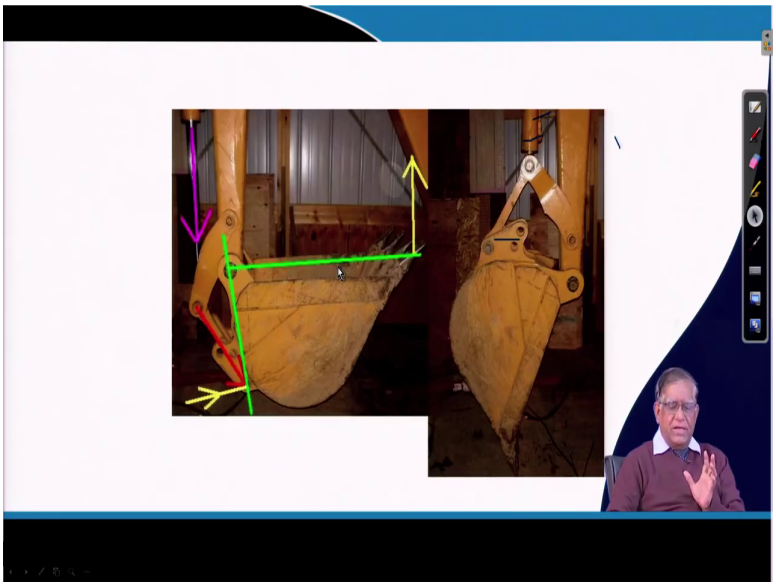

So, then while in applications your main importance is that how much exactly we are producing, that will be depending on the dimension and the capacity of the bucket. The bucket capacity is depending on that how what are exactly different forces coming on to this bucket and there you can find out how it will be used.

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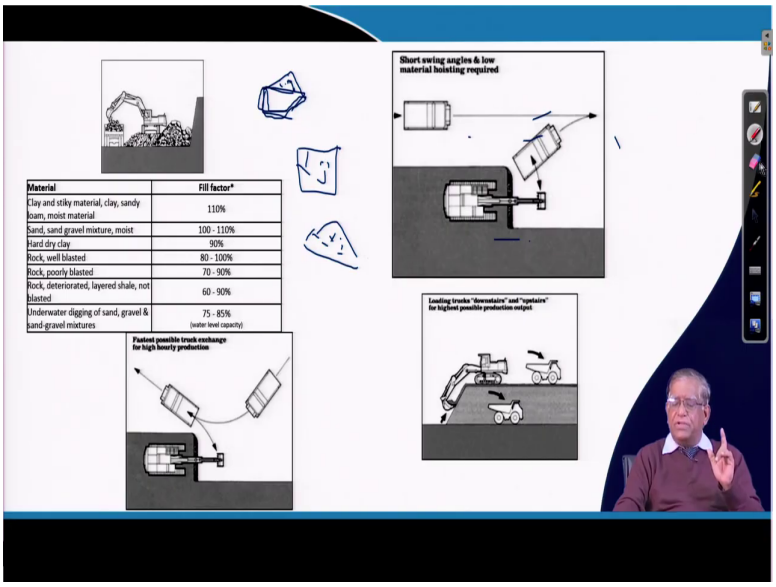

Say for example, there the bucket fill factor; that means, the bucket cannot be filled whatever the bucket capacity it is. Sometimes if it is the if the bucket is of a particular bucket is here, so you can get the material filled like this that is called your heat capacity.

When it is a heat capacity bucket fill factor can go 1.1 times or sometimes even more. But thing is that many a time the bucket is just filled like a your glass you are filling it over here, the material is only within this then it is called your struck capacity; that means, it is a 100 percent.

But what happened in the bucket you seldom gets this because, if the material is sticky when you are unloading there will be some layer of material will be lying inside this bucket which is not good totally going out. Then the bucket even if you are putting over there the filling

when you take the material out and then you measure it, then you find out that this capacity is much less than the struck capacity.

That means the bucket fill factor is now less it can go as less as 60 percent that is 0.6 that is the whole capacity if the material is getting sticky over there then you cannot fill. Moreover while in operating you will have to control the breakout force, if you are not doing it properly then also bucket does not get filled.

And then sometimes if you take a lot of time to fill it fully by that time exactly you will be losing the cycle time. If you are in 30 second you are supposed to load a truck, if you are taking more than 50 second to load the truck; that means, number of trips will be less. So, ultimately the mine will be producing less.

That is why sometimes the operator he will not bother about that whether it is filling 100 or 110 percents you will do and try to manage the time within that time that is why it does not get fully filled and you get about 70 percent 80 percent of bucket fill factor. So, this is what is very important to know that the bucket fill factor it exactly your hourly production capacity of the machine can be affected by that. So, you need to be careful about how it is done.

So, then this is exactly how the back hoe is operating, the truck it can do that operationally in some phases your say you can load 2 trucks 1 is coming over 1 is coming over there that whether you will be using this or not. There you can simulate that the simulations of the operations over there, that truck will be travelling some distance to dump the material and come back that distance is called your lid distance.

Depending on the lid distance and depending on the velocity of the truck on load full load and without load they will be requiring some time. And during that time your this truck is loaded and it has gone by that time that truck must be coming over there and ready. So, that there is no queue and there is no obstructions on the operations.

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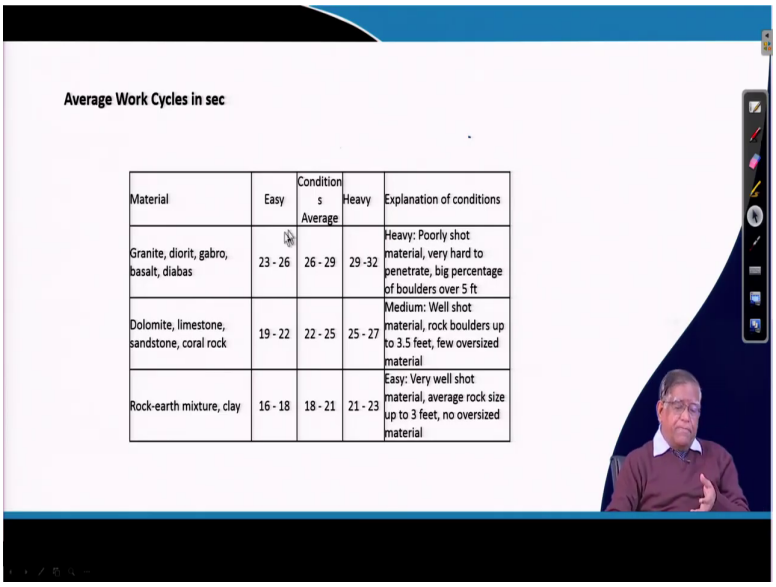

So, like that your face need to be simulated and then the operation cycle depending on the different material, because in a easy digging cases there could be within 23 26 second you can do it. And sometimes say some of the sandstones and all which are very difficult conditions to operate there your that time requirement will be more.

So, that is where how the cycle time get very material to material, whenever you are doing designing and whenever you are doing your blasting in surface mining you will have to see the how the fragmentation is there. If the fragmentation is not proper then your cycle time for loading it by shovel will be more and then it will be exactly your productivity will be going less.

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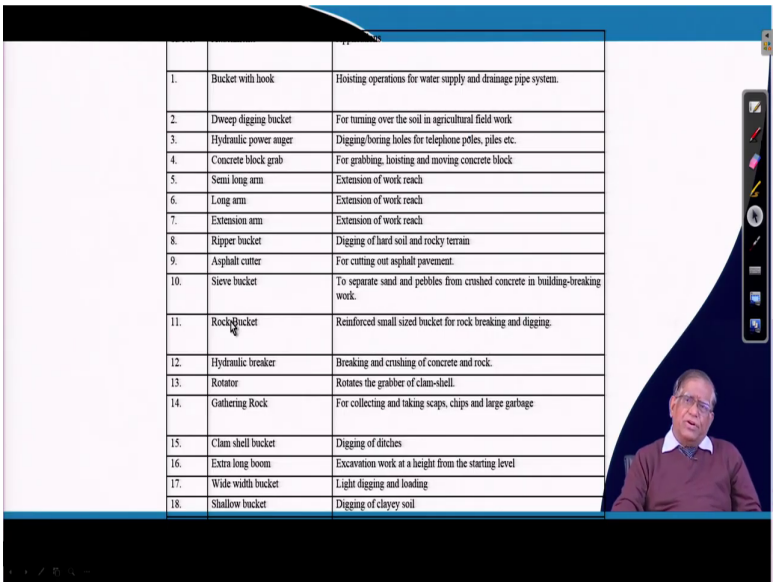

So, all are related that is why while learning surface mining you will have to know how different fragmented material will be loaded over there. And then this different material that they may that is that when you are having using a bucket for the excavator. But you can remove that front attachment and you can collect different type of front bucket different type of operating things that is called in a hydraulic excavator; by changing the front attachments you can make multiple use of this machine.

So, this is also very important thing in hydraulic excavator that 1 machine can serve you different things, maybe sometimes the same bucket excavator you can have a grab bucket type of loader or sometimes you can have a say depending on the material you can change the bucket so that the operational efficiency increases.

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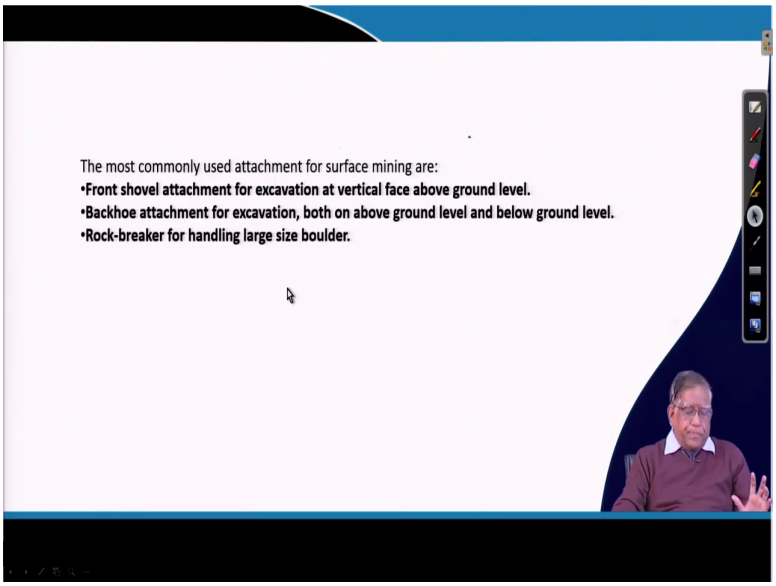

So, there are the front shovel attachments backhoe attachments and the rock breaker these 3 are mainly used in surface mining.

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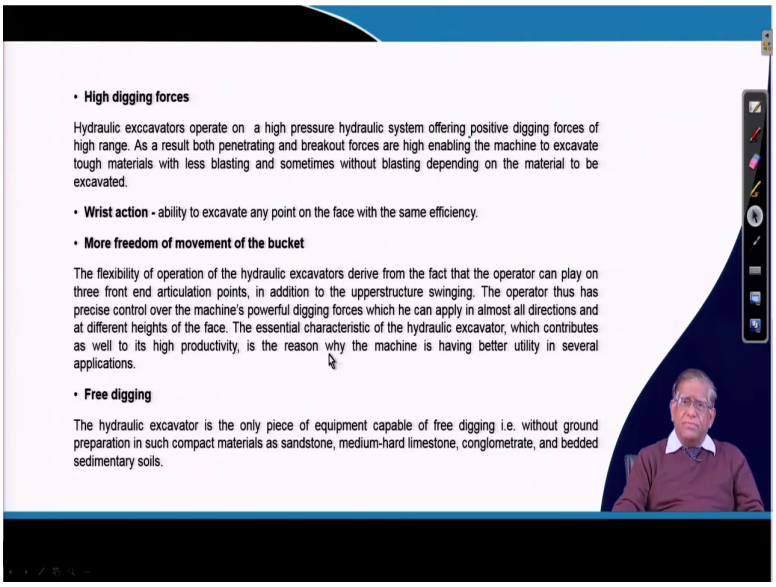

And then the advantage of this machine is it can give a high digging force, it has got the wristing actions, it is a more freedom of movement of the bucket, it gives a free digging.

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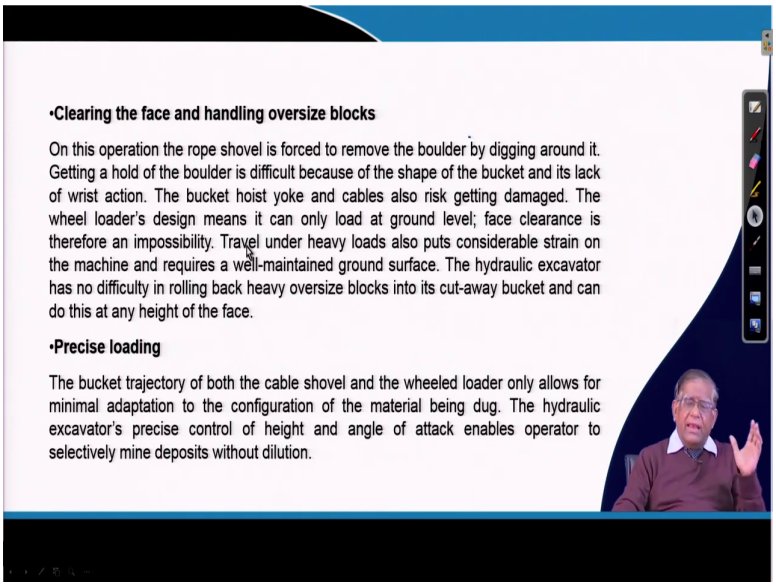

It gives a clearing of the face also can be done by it, it can do a very precise loading.

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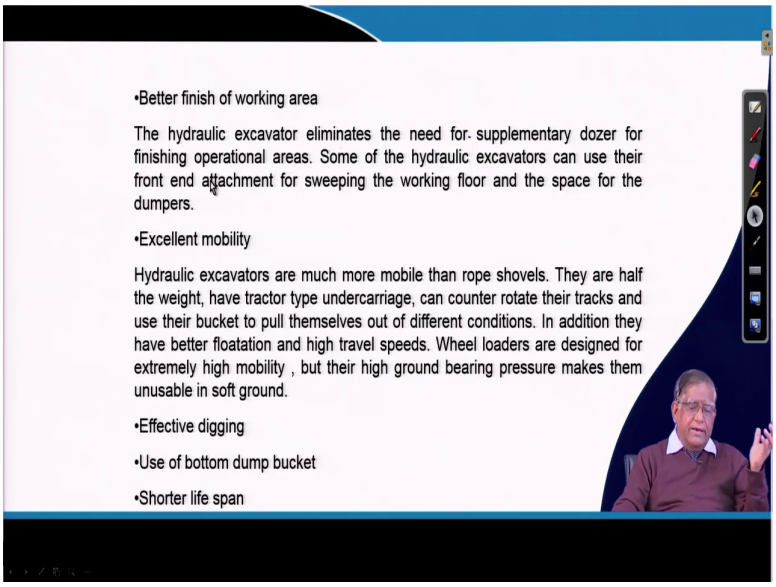

And then it has a very better finishing of the space can be done, it has got excellent mobility, it has got effective digging efficiency is high and use of bottom dump can bucket can it will easily you can change the design of it and it is a that only thing is that its life span is shorter.

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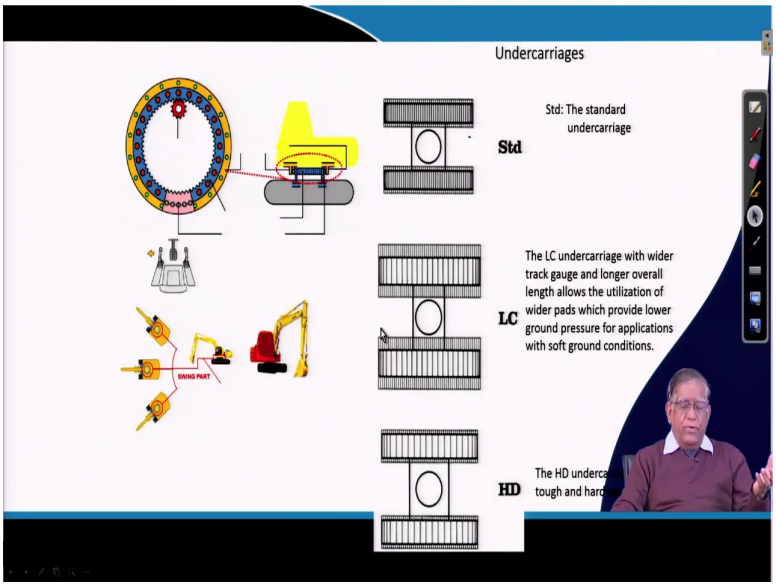

So, now you can find out that how exactly the undercarriage is rotated, you can see that in the undercarriage there is a turntable in the turntable inside there is a sun gear. So, this is a swing gear, if your motor is rotated over there this outer this platform will be rotating. And that is how that exactly the shovel can be this your front attachment can work that is swinging operations is done.

And this operations by just adjusting the control of this swing motor, the swing gear running in this sun gear this can be rotated and then the supporting undercarriage is these 2 crawlers are there each of them will be having a separate drive. So, by controlling 1 drive you can steer these things.

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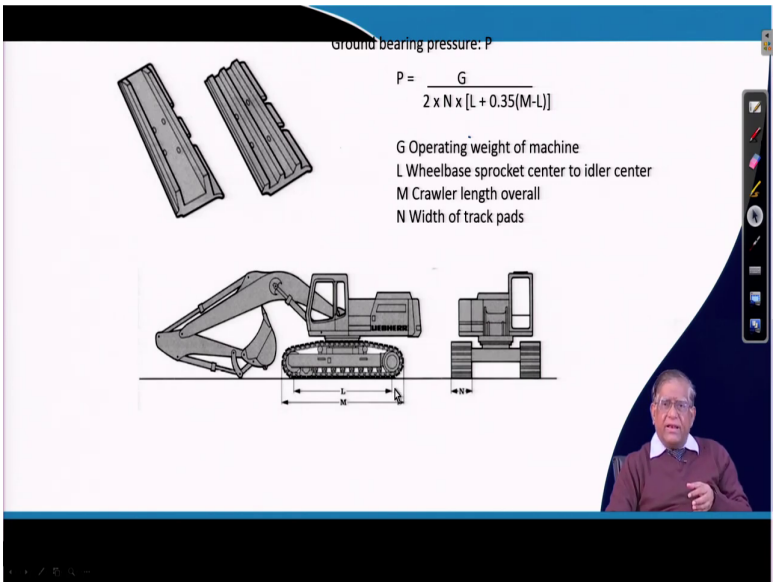

So, these are the you can see that this how the crawlers pads are there, these pads make the crawler chain and they do it. So, this exactly because of the weight of the machines there will be pressure on the ground, that ground pressure is very very important. If the soil on which you are working the rock on which working it should be able to bear this load and that is called your ground bearing pressure.

That ground bearing pressure depends on the total weight of the machines with load and then the dimension of this chain crawler chain. So, this is the exactly see this whole crawler length it is not supported only this L part is getting supported over here. So, this is the equations you can note it down that for the ground bearing pressure depends on the operating weight, with the wheelbase sprocket to sprocket length and the crawler length and also the width of the track pad this exactly is very very important parameter.

Depending on if your geo mining conditions during the rainy season what is the ground bearing pressures, if it is very low then this machines will sink over here and then the operation will be difficult.

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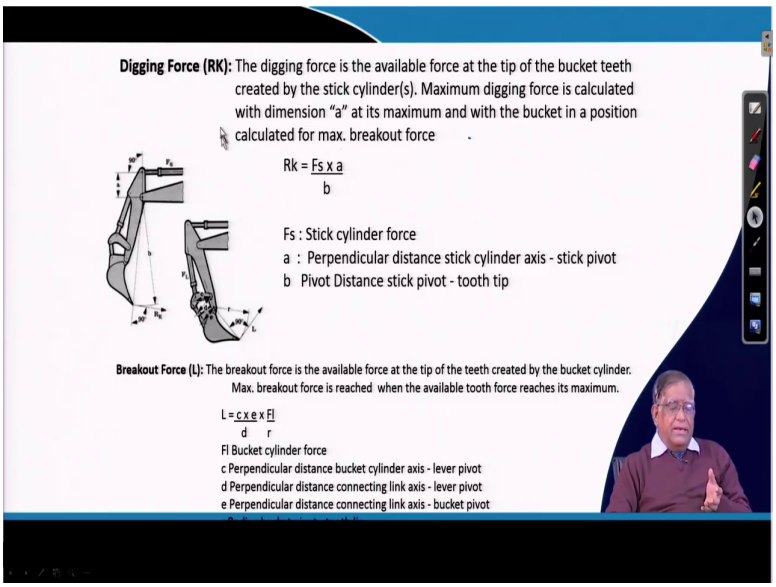

Similarly, the digging force here how much digging force will be coming it depends on the dimensions of this arm and this forces. So, this is depending on the what is the stick cylinder force that exactly and the distance between this perpendicular distance from the stick cylinder to the axis.

And the pivot distance of the stick power, that is by this simply balancing of the forces you can use the couple and then there is you can easily find out this equations of forces. So, this is

why you will have to do that what is the breaking force what is the digging force you can calculate out.

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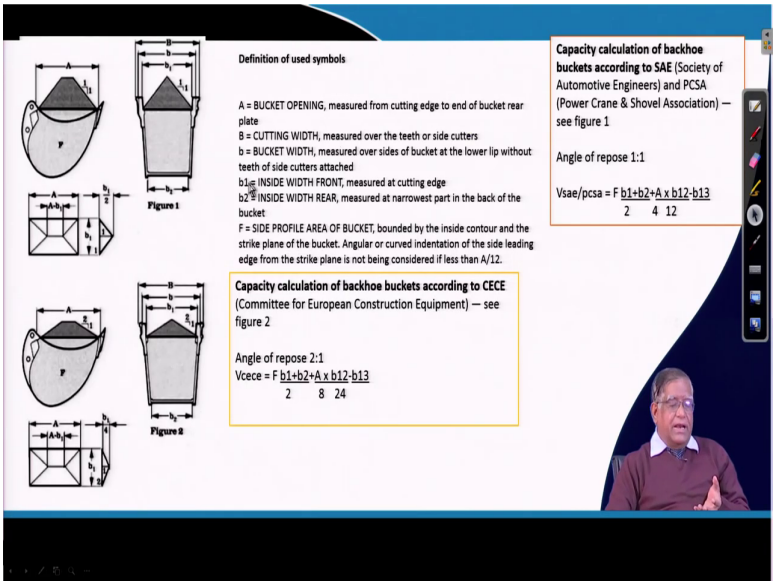

And as I said that how the capacity of the bucket is determined, there are different type of bucket this profile that bucket bottom profile why you make it such curve. Because the material will have to get filled into the bucket and also get evacuation easily now when you push into the bucket the material first will go and then there will be a friction coefficient of friction of the this surface and the material that will make in what speed it will be moving over there.

And then when some material is over there then depending on the cohesion of the material there will be a different type of movement of the loose material inside the bucket. So, to facilitate that you design a curve, so this that this particular curve why it is? So, it has been

taken under certain conditions has been taken that this type of material will be very easily get filled into it.

So, the capacity calculations of the backhoe bucket you can find it out, it will be depending on the capacity is the dimension of the buckets from there it is there certain formula this society of. This in say SAE they gives lot of these automotive engineers there are standards there, you can find out that how this calculations are done.

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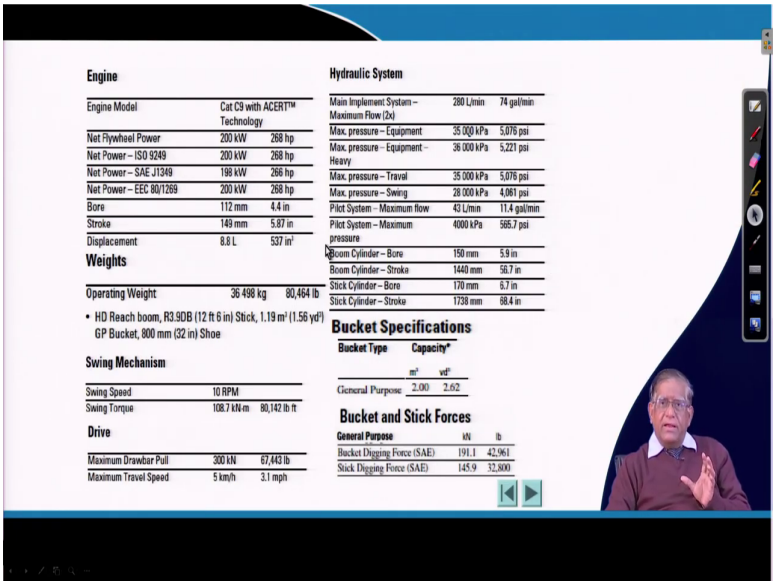

Now, you make a study of the different leaflets of machines and calculate and find out what is the range of.

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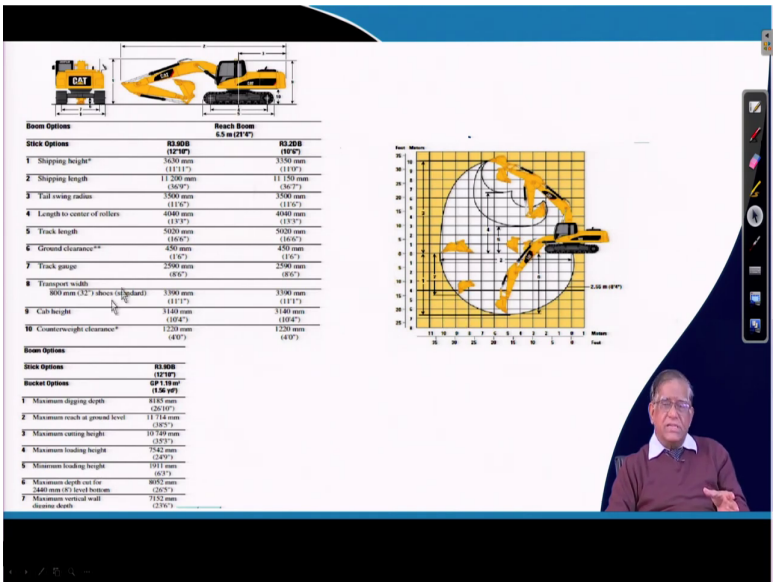

This exactly the different forces and different parameters you must study the leaflets of the machine.

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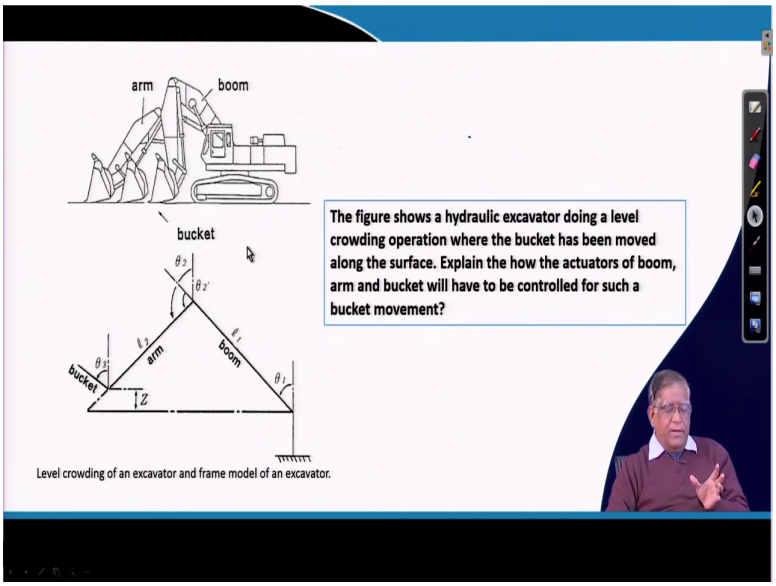

And then you can find out what is that how different configuration of the boom can be there to which distance it can cut this is also an exercise you can do over here.

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And then your the front attachments as I said it can be it is a grab bucket, it can be rock breaker, it can be a this is your vertical ripper, it is a different type of grab bucket. This type of material can be ends by just changing the front attachment of the hydraulic excavator.

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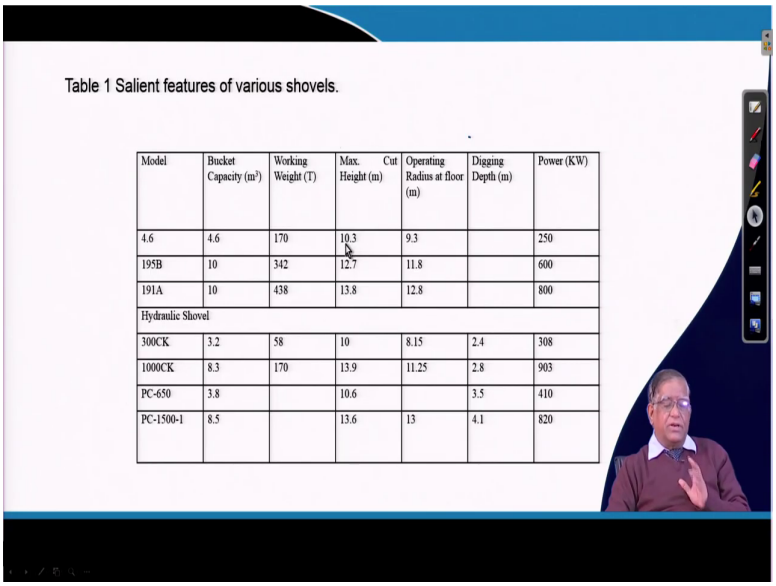

You can do a lot of other work.

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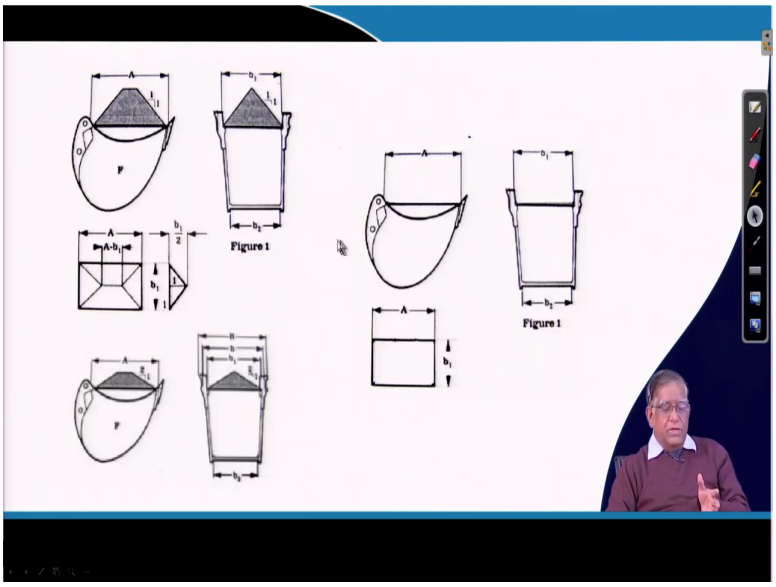

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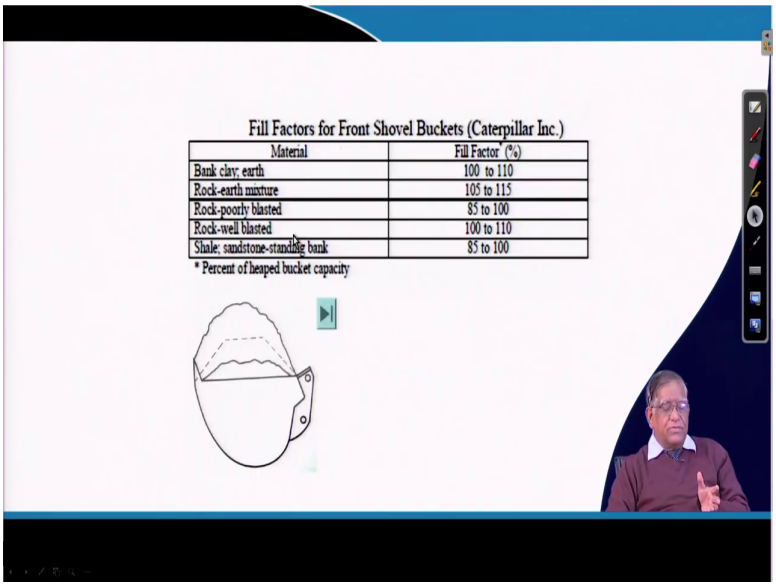

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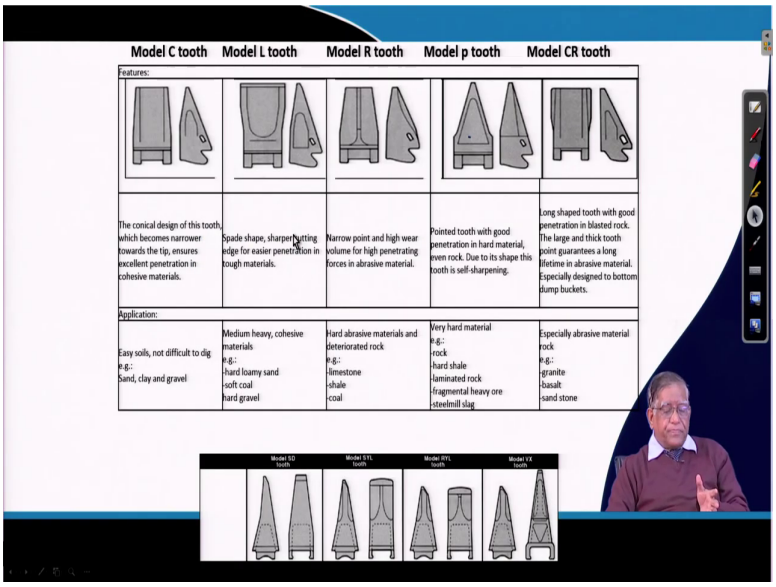

So, this is the teeth of the bucket they can be also of different because the teeth will get wear out and then you will have to maintain it properly, that when operating with these basins that teeth their wear is a very very important things. This is one area where you can study for the getting a new innovative material and then the how the teeth will be fitted over there.

That also is a very important things because that to maintaining the teeth; that means, the old on teeth will have to be taken out and the new teeth will have to be fitted. So, you should design in such a way that the time of your removing and fitting should be very less.

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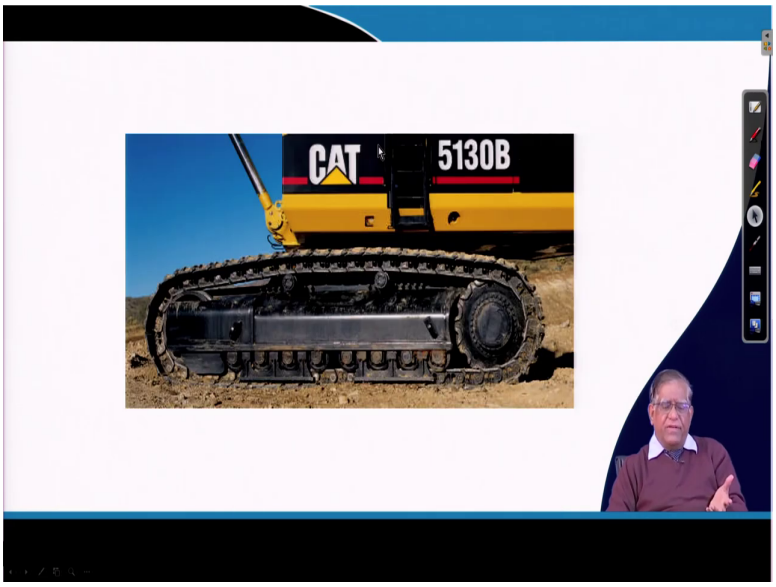

So, that is the way it is done.

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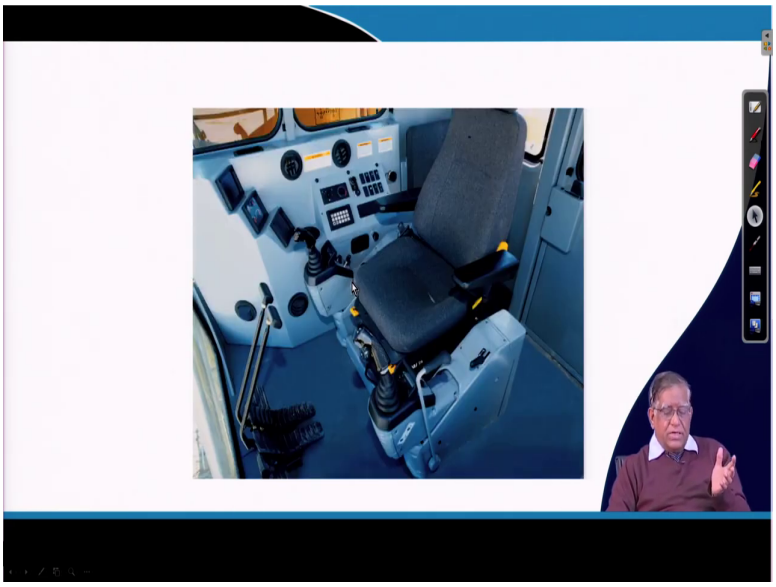

So, there is a main crawlers and you can see the ergonomic design of the operators cabin, that is now it is modern this hydraulic excavator has got a such sophisticated operations. And you know that the in Australia many of the this your machine operators they are all graduate engineers earning about 12500 dollar Australian dollar a year. So, this is highly of sophisticated operations many of the engineers can aspire to become a very good operator, because they will be changing the productivity of the mines.

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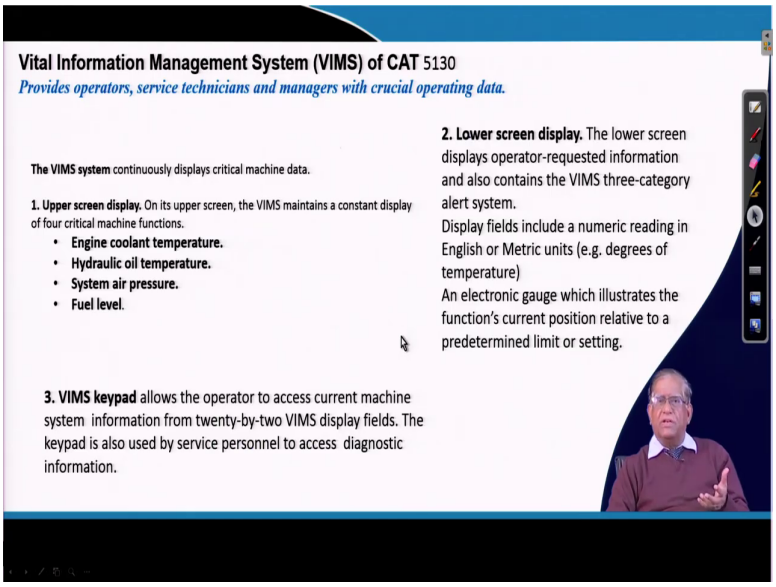

So, there is a in the modern machines because of the mechatronics development with the sensor technology and all now all these things are data driven. To take a data driven decisions these are that machine information systems have been developed.

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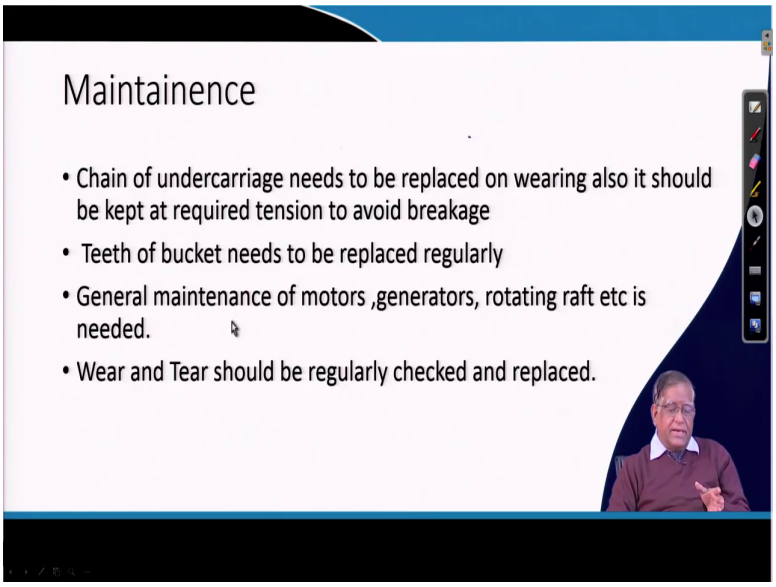

The different parameters are collected and from that parameter it is exactly you take a decisions for the operations maintenance and management of this. So, that ultimately the productivity is reached and you get a very good financial aspects. And of course the maintenance the every machines will be giving a maintenance schedule of the preventive maintenance schedule will have to be there, but the most care should be taken about the undercarriage because if any leak breaks then it will take a long time.

That the other general equipment and the teeth maintenance and the wear and tear that is other, other than that there will be some problems and troubleshooting you will have to learn for the hydraulic systems, because many a time the hydraulic systems can give a problem.

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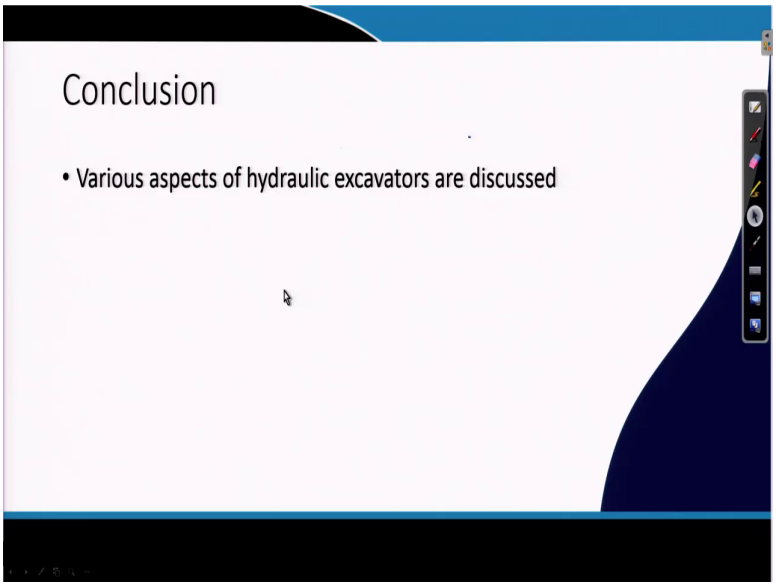

So, in a nutshell you have learnt today what is exactly a hydraulic excavator and how it is to be selected for. And then I think after this discussions we have discussed 2 machines electric rope shovel.

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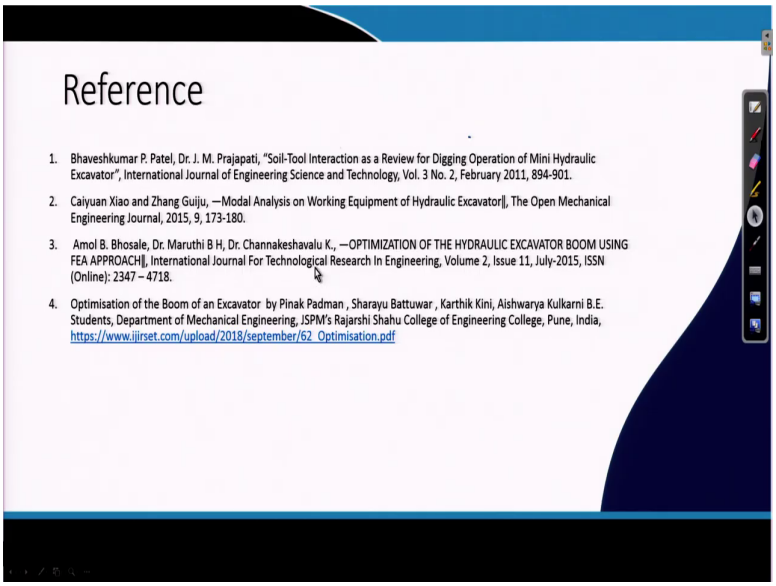

And hydraulic excavator please prepare a comparative table of these 2 machines what can be done by electric rope shovel and what can be done by your hydraulic rope shovel. And then you study different material from the nets and then you can come forward, so that you try to explain with your own words what are the differences between these 2 machines.

Thank you very much.