Mining Machinery
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Module - 06
Lecture - 32
Underground Mining Machinery Shuttle Car

We have discussed so far, the coal winning by continuous miner. Now, once we get the coal by continuous miner, we will have to be transported from the phase and to take out of the mine.

So, these operations are done by some of the transporting machinery. Normally, the evacuation of coal from underground coal mine to the surface, it is done in bord and pillar mining, you have heard about this by your mine car, locomotive and then, one of the advanced method is transported by conveyor belt.

Now, when you are getting a material, getting the material from continuous miner that means, it is continuously excavating, then the transporting machines will have to be also a continuous, then only you can get a higher productivity. So, to get a conveyor belt loaded, it will have to have a proper feeder and many times in the mines you use feeder breaker.

Now, to the feeder breaker, it will not be placed just near to the phase because the phase after this coal is excavated, then the roof will have to be supported and then only it can do. So, the conveyor belt will be up to a distance. Now, from the phase to the distance that is where some transporting machine will have to shuttle, they will have to come from the phase to the conveyor belt and all that operation is done by shuttle car.

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Now, like we told about this your rocker shovel, a very old machine, this mining machinery this particular type of machinery is also a very old machine. It started even I think in 1880's also, this type of machines were used and then, it developed over the years. Now, today is the modern shuttle car, which is manufactured by many companies like Joy or the Sandvik or Caterpillar.

This shuttle car is a special type of transporting machine used particularly in the underground coal mining or it can be used even in metal mining. This machine is basically a rubber-tired machines as you can see in this figure that it has got a system where the material will be brought from the continuous miner over here on this carrying things and there is a operators cabin and it will be moving from the phase to where this material will be transported to that.

So, this is why it is an intermediate transporting coal transporting machinery used in a underground coal mining. So, there is normally, when the where there is no track say if it is a loading to the locomotive or loading to the conveyor belt where there will be a conveyor belt line, now from that where it the conveyor belt ends, there the area of shuttle car starts, it is a electrically powered machine.

Now, we will be discussing about the construction and operation and maintenance of this machine and which is used for the purpose of transfer of coal from the continuous miner to the feeder breaker or conveyor belt. Now, whenever it is going to be loaded the excavated coal that is which is cut by continuous miner, sometimes big size boulders also may come in and on through the shuttle car.

But that material if it is to be transported by conveyor belt up to the surface, the conveyor belt, which has got a limited thing so, in many times, there is a necessity of breaking the coal to a smaller size to be compatible to use in the conveyor belt and there we use this feeder breaker. So, we will be discuss later on something what is that feeder breaker or under the what are the other type of handling, crushing, screening are done with coal.

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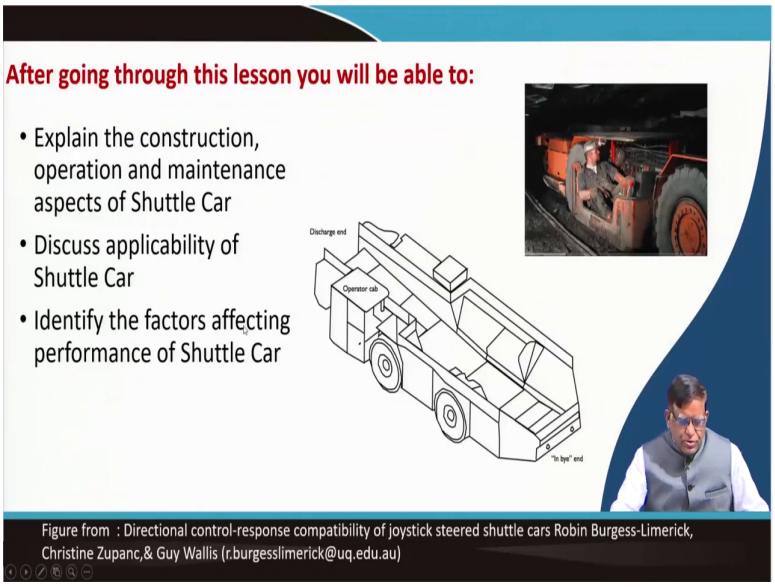

But to this machine, after this class, you should be able to explain that how it is constructed and then, how it is applied and how it is exactly to be maintained for getting its productivity that you will have to study. You can see over here that this is a low profile that is a low height machines working in the gallery.

As you have said that continuous miner can work in 1.8 to 5 meter so that is why you can see depending on the type of seam, there could be a very small that is thin seam shuttle car could be there as well as there could be a thick seam shuttle car, it can be designed depending on the type required.

But basically, this machine is looks like a you are having a space for loading the coal, a operator cab is there, a for the there is a in by end and the out by end that is discharge end where from the material will be loaded from this side and it will be this taken out and the

other side. So, that material from here to the end is taken up by a chain conveyor which is loaded over here.

So, you can see the operator will be sitting by the side of it, you can see that the in a very low different positions you will have to sit and this operators cabin must have a proper roof so that any follow up material because this machine will be working under unsupported roof in many times.

So that is why this type of protection systems are there, all the controls so, this will be in front of him. You can see the operations will be done in a different position. So, the ergonomy of it is the way he is so that he is what will be his fatigue, what will be his comfort level, these are also nowadays studied and then accordingly the machines are designed.

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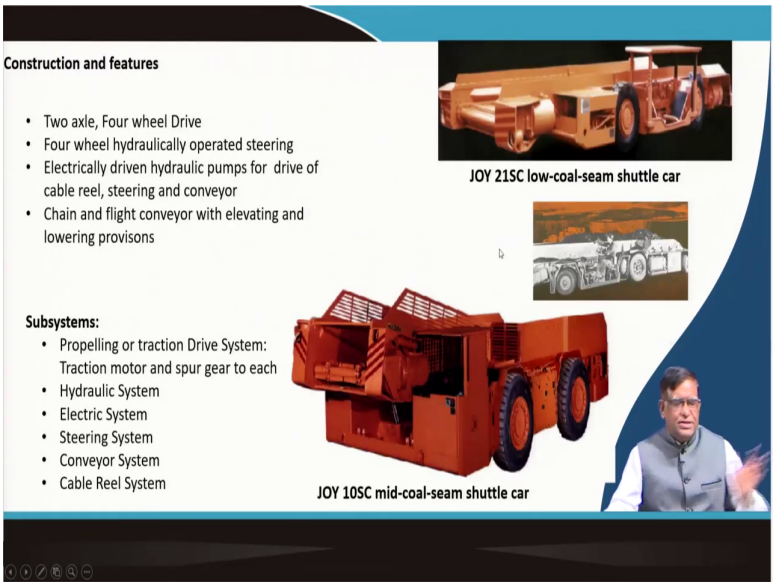

So, coming to this construction wise as you can see from that figure this is a from the figure, once very old shuttle car is also shown over here that is a it is a comparatively that before the previous figure, this figure is a very low height, here is a medium height, there we can have the operator can be sitting by the side of it.

Now, this basically there are two sets of two axles are there where your four wheels are there each of the wheel will be in depend independently driven four-wheel drive. Now, as you see that in underground mine that depending on the slope at which the continuous miner is deployed as I said that it can work in one in eight. So, there and then, many times there will be slippery roads maybe because of the water is coming onto the seam.

So, the road conditions can be difficult and there will have to have the for proper tractions a four-wheel drive will be necessary. And then, the steering also at the four-wheel that steering motions are steering power is given and this will be the machine is a powered by electrically.

So, up to the wherever that your main electric supply is there underground from there a trailing cable will be coming and that from the trailing cable, the power will be brought to this equipment where there will be the transformer, from there it will be driving the motor for driving the pump and then, there are certain operations will be done by hydraulic motors.

Nowadays of course, that is your with the development of the that is a variable speed your frequency, variable frequency, variable speed drive, AC drives are now given otherwise there would have been a different type of DC motors were there in the past, but now there are advanced control systems over here, we will be talking about it.

Now, the conveyor belt which is at the discharge end, it will have to load onto the conveyor. So, depending on the conveyor belt, it can be raised and lowered. So, the discharge end of the shuttle car as having a elevating and lowering arrangements. So, thus these constructional features can be considered that this machine is comprising of some subsystems, which will be a propelling or traction subsystem that is your a traction motor will be here.

And that from the traction motor through a gear that a spur gear, the material that is the power will be given to the wheel drive, there will be a hydraulic system for controlling the razing and lowering and also for steering the hydraulic drives will be there. There is a electrical system, which could be for your lighting, for braking and other purposes electrical processing is there, steering system, then conveyor system that is the main centrally that chain conveyor we have seen.

Then there is also a cable reel system, that cable which is connected over there as will be going near to the that is your loading point, the conveyor belt will get reeled up and when it will be coming from the loading point back to the your discharge point to the loading point, the conveyor that cable belt will get unwind and these are all will be getting with a automatic cable reel system.

However, a persons will be there to take care of the cable so that it does not (Refer Time: 10:12). So, there are different features are available and this machines work in that way.

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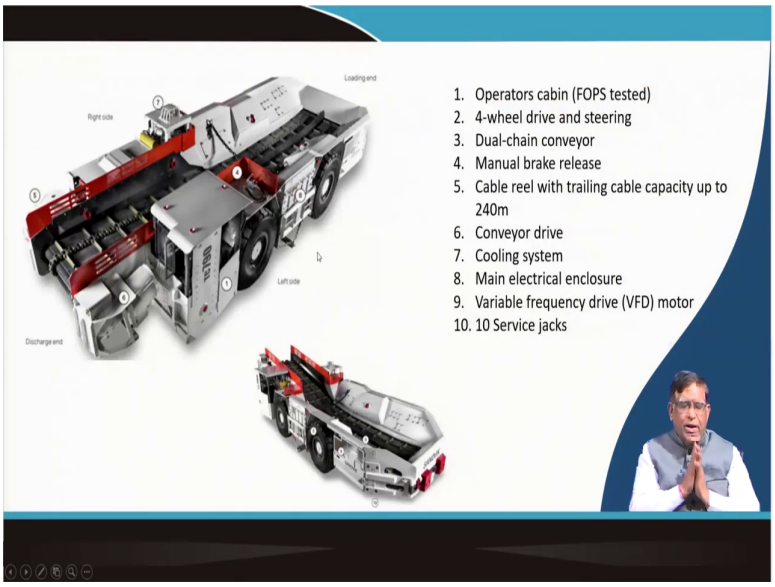

Now, in this figure, you can see the different component in a much clearer way. So, that means, this machines as a operator cabin is there, you can see this operator cabin it is located, which is ergonomically designed, a modern of machines has got a very good that comfortable positions and it is all the levers and all are very easy to operate, he can work in a dust free, noise free surrounding inside this cab.

Then, the steering is there for the four-wheel drive steering in the wheels that is provided over there. Then, there is a dual chain conveyor, sometimes they say you can see here, this conveyor can be a centrally one chain and then the flight bars or could be a dual chain at the end and here two chains will be there, in between that flight bar will be connected.

And then, there could be a your brake release, that brake will be released by the that is operator it can be manually released brake, then there is a your cable reel is there that where

machine will be moving towards the phase to the discharge point that cable, electric cable will get that. So, up to 240-meter cable can be accommodated in the machines. Then, for the conveyor belt that is chain conveyor, it has got a drive motor for driving it and then, it will be having the coupled with the gearbox.

Now, this as because sometimes these machines will have to be started with a full load, whole load of coal is lying over here, under a total heavy load, it will have to be that this motor will be connecting to the shaft of this sprocket on which it is a chain is mounted that coupling will have to be a fluid coupling so that your starting, initial starting is easier. So, this you have studied already regarding how a fluid coupling works over here.

So, then, there will be a cooling system because this is all the your heat, which is generated will have to be air cooled, water cooled and then, this your that cooling system will be there, then there are that your main electrical enclosure that is all electrical components are to be kept under, it should be a flame proof enclosure and that all circuitry should be intrinsically safe circuit.

Then, your this is a main motor that is which is exactly a very variable frequency drive motor and then, there will be some service jacks, sometimes it will have to be if any work is to be done, it can be raised lower tire changing and all can be done by operating with the jacks.

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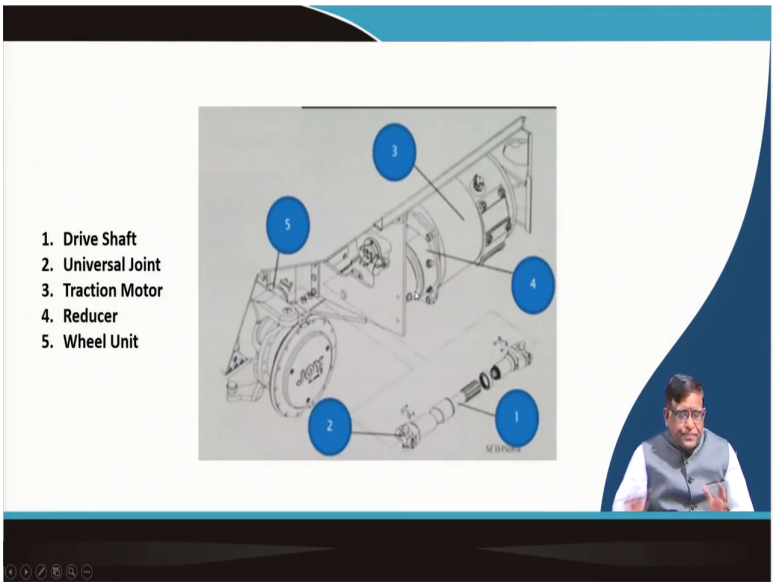

So, you can see that how the driving is done, you are having a drive shaft for the drive motor, which will be connected with an universal joint over here and then, there will be a traction motor, from the traction motor through a gear box the power will be coming to the wheel unit. So, this is there located at the side and this arrangements are there.

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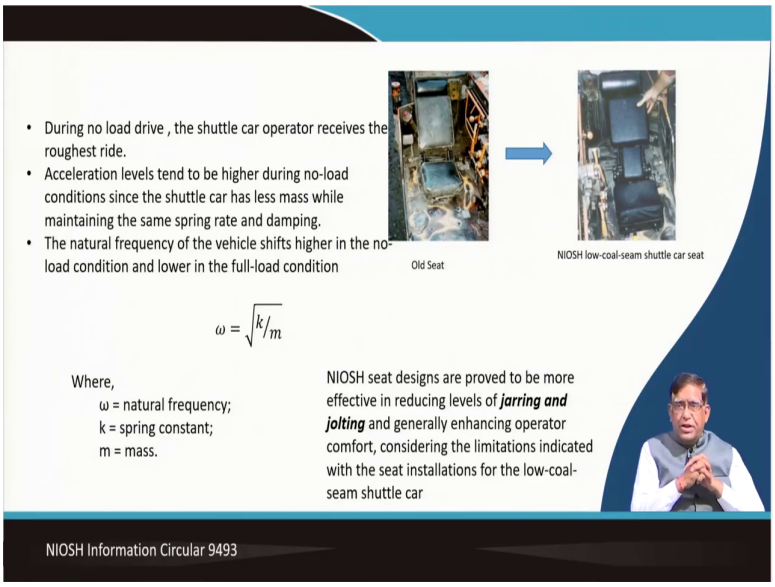

You can see that the operators comfort is very very important things and the operator seat, it has undergone various research and studies. Now, the main operation, main things as you have seen the it will be working on the very rough workflow that is the tracks and the roads on which it will be moving in the gallery, it is not always a smooth. Now, the when the loaded vehicle is going to the discharge point and while returning from the discharge point, the empty one at that time, there will be very less weight of the machine.

When the weight of the machine is less, it will be subjected to vibrations because as you know the natural frequency, which is given depending on the spring constant which is for that machines suspension systems and all that is be working as a on the speed constant. Normal equations you know that the they it is inversely proportional to the square root of the mass.

So, as this must reduce after the this after unloading the material, the machines will be coming with a heavy vibrations and there if you are sitting on a different awkward positions, then your whole body will be getting a different type of vibrations. So, NIOSH that is your the American safety and health organizations, they have developed new types of seats, which will be having that operators will be free from jarring and jolting type of things and he can work comfortably.

So, this is a, this type of machines are nowadays for the health and safety purposes, it will have to be having this. So, this there are depending on the height of the machines that your how the seats can be made more comfortable, this is a matter of study everywhere this type of studies are carried out.

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Then, that a lot of development have taken place to this 1880 model. In 1980, when this our variable frequency drive was introduced after that, all the shuttle cars which are being manufactured today are all having advanced feature. Now, there is a first thing was the development came with the suspension systems.

You can see here that the suspensions each and every wheel is having their own suspensions so that the undulations and that jerk vibrations and then, the that operator can get a better comfort. Now, in the operators cabin, we have got a revolving chair with the whole air condition room everything can be provided to do it in a very work very comfortably.

Nowadays also you can see that in the screen in front of the operator, there is a screen over here with a TV screen on that you are having the rear side and the front side, both sides that your the monitors are there so that whenever it is going to load or unload, if any person is there in the back side, the operator can easily see.

So, earlier it was very difficult and that is why the operator was sitting on the side and so that he so he could see if persons are standing over there on the low height so that time it was only on his visual line of sight, the safety were maintained, but today, because of this your high visibility that your camera in by another facing camera that you can improve the safety with this.

Then, also the comfort level has been improves. Overall the machines, it is a speed; speed has increased with the your frequency drive that is your variable frequency drives that VFD as it is called that the this model that is exactly their drive has been named as opti-drive, this is a Joy they introduced this a opti-drive in 1980, from then onward that exactly the performance improved.

Because its speed increased from 6 kilometer per hour to 9 kilometer per hour and that speed increase means that cycle time decrease and the productivity increase. So, what exactly you can do here that is your you need to study that one of the major modern equipment that is a

Joy's 10SC42, this is a model, 10SC42 is a model with all the modern features and how they are exactly bringing in more instrumentation into this machine.

So, you please collect the specifications and compare to some of the shuttle car which are available in 80's and 90's so then, you will find out the trend of development. Now, in near future, what type of development will be there? That is mainly man-less operations, remote control operations are will be coming. So, there you can do some more studies so that the you can improve this machine by your input.

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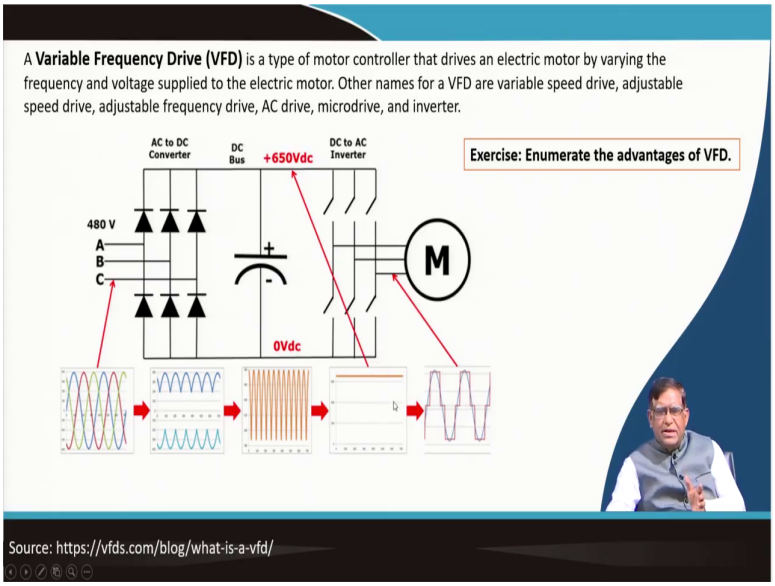

Now, when we say that there is a Variable Frequency Drive now, what is it exactly? You might have seen that our three-phase; three-phase motor that when Tesla introduced in 1880's at that time that your motors they say electric three-phase motors are coming, it has got one major disadvantage that you cannot control the speed.

So, then later on, this today modern variable frequency drive, it basically has got a combination of a converter and inverter. Now, as this three-phase power is coming and there is this converter where your this diodes, which allow only one directional current to pass, then you are having an inductor that is exactly this capacitance we are having, this will be leading to that you are getting a the DC current over here with a one we are getting a steady flow.

And that one, when you are giving as an input to the inverter, it will be again giving these pulsations. Now, for controlling the speed, you only just change this frequency over here and then, frequency and voltage change will be changing the speed. So, by that way, you are getting this variable speed. Now, when you are required depending under your requirement, if you are working with that the required speed by that what is happening?

Your total energy consumptions will be going down. So that means, your total in the production cost, the total energy electricity demand cost will be also decreasing. So, that is way, how exactly a variable frequency drive from your converter, AC converter to and then having after converting to DC, then again it is cutting to a DC to AC inverter, and you are running this three-phase motors for driving the vehicle. So, this type of this development has exactly improved it.

So, you can easily study about this please take this assignment, take a enumerate the advantages of this variable frequency drive and because this is not only in that the our shuttle car in continuous miner, in many of the mining machinery including surface mining machinery, this is that variable frequency drives are now being used. So, why these are used? Make some study of it.

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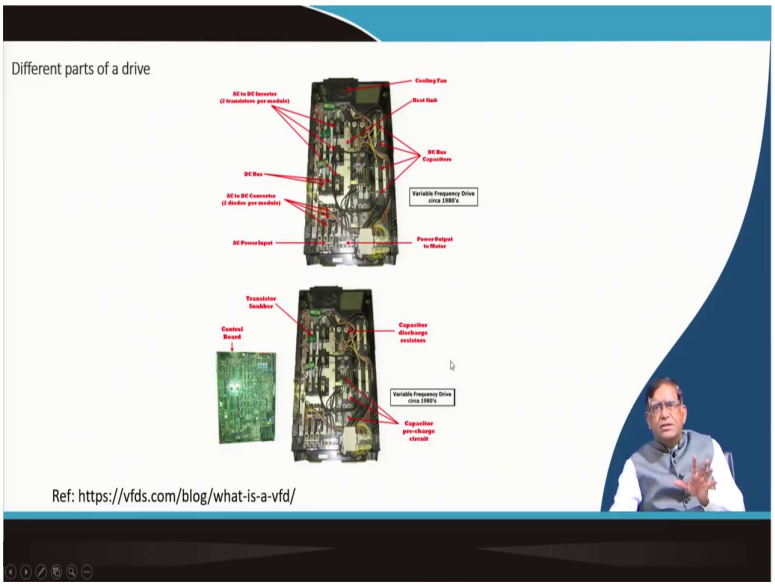

If you see here, in a what it looks like inside a variable frequency drive? You can see that when the AC power inputs are brought over here, then it goes to the converter circuit, from there those diodes and rule will be giving to a DC bus and then that DC will be now AC to it will go to a DC inverter and from there it will get into that with the capacitance, you are getting DC and then ultimately, you are giving the power output to motor is coming from here.

So, this arrangements that where we are having a your the transistor that is your snubber is there, all these arrangements are kept within this and you are controlling the that your voltage and frequency for doing that giving that particular speed and to the motor, you are having a control board and this is incorporated in the machines.

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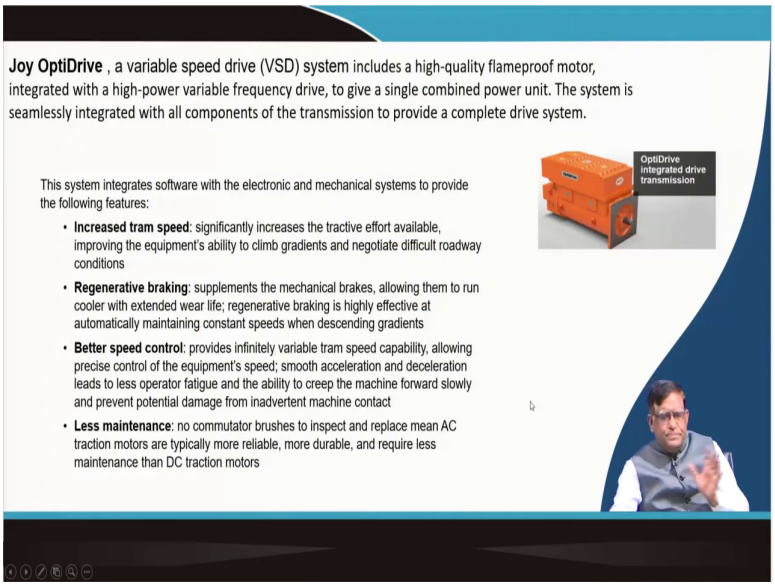

So, the Joy, when they brought this opti-drive in the late century, after that this has exactly got tremendous market advantages. So, there this looks like a this one something here, you can see the specifications from the that manufacturers manual. Now, they say they have got many features particularly that is your increase in the speed, it helps in the regenerative braking, you try to understand that regenerative breaking is that your, if you are that is the it will supplement the your mechanical brake.

And then, it will also help in that is if your electrical you are braking, then in a mechanical brake, there will be heat generated because of friction that will not be there in the regenerative brake, then, it will be giving you a better speed control. And while you are coming from your DC drive to AC earlier because of this variable speed and control, the motors were DC motors.

Old machines say even that in the 80's, 90's, most of the mining machinery there where the motors are DC motor and that DC motors have got that you are exactly this for the slip rings and that carbon brush and all that maintenance costs are always high. So, with this advancement that exactly has led to our less maintenance or that means, your gain in the cost.

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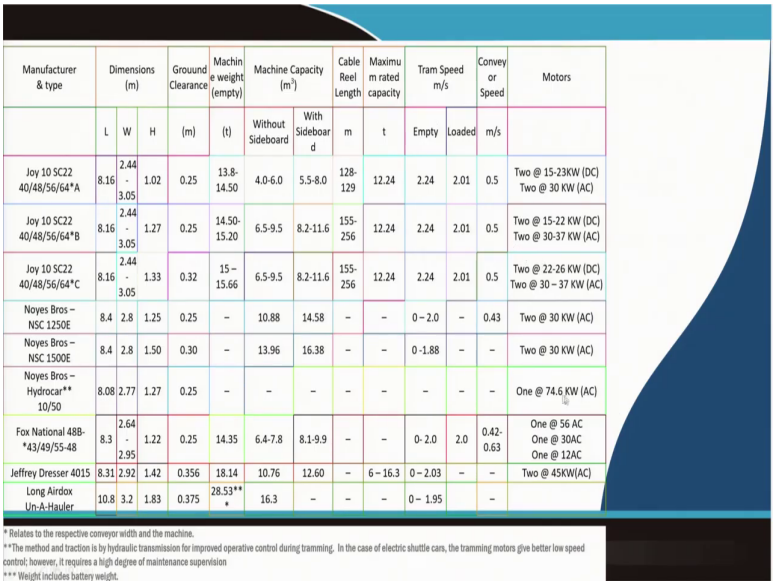

Manufacturer & type	Dimensions (m)			Grouund Clearance	Machine weight (empty)	Machine Capacity (m^3)		Cable Reel Length	Maximum rated capacity	Tram Speed m/s		Conveyor Speed	Motors
	L	W	H	(m)	(t)	Without Sideboard	With Sideboard	m	t	Empty	Loaded	m/s	
Joy 10 SC22 40/48/56/64*A	8.16	2.44 - 3.05	1.02	0.25	13.8-14.50	4.0-6.0	5.5-8.0	128-129	12.24	2.24	2.01	0.5	Two @ 15-23KW (DC) Two @ 30 KW (AC)
Joy 10 SC22 40/48/56/64*B	8.16	2.44 - 3.05	1.27	0.25	14.50-15.20	6.5-9.5	8.2-11.6	155-256	12.24	2.24	2.01	0.5	Two @ 15-22 KW (DC) Two @ 30-37 KW (AC)
Joy 10 SC22 40/48/56/64*C	8.16	2.44 - 3.05	1.33	0.32	15 – 15.66	6.5-9.5	8.2-11.6	155-256	12.24	2.24	2.01	0.5	Two @ 22-26 KW (DC) Two @ 30 – 37 KW (AC)
Noyes Bros – NSC 1250E	8.4	2.8	1.25	0.25	–	10.88	14.58	–	–	0 – 2.0	–	0.43	Two @ 30 KW (AC)
Noyes Bros – NSC 1500E	8.4	2.8	1.50	0.30	–	13.96	16.38	–	–	0 -1.88	–	–	Two @ 30 KW (AC)
Noyes Bros – Hydrocar** 10/50	8.08	2.77	1.27	0.25	–	–	–	–	–	–	–	–	One @ 74.6 KW (AC)
Fox National 48B-*43/49/55-48	8.3	2.64 - 2.95	1.22	0.25	14.35	6.4-7.8	8.1-9.9	–	–	0- 2.0	2.0	0.42-0.63	One @ 56 AC One @ 30AC One @ 12AC
Jeffrey Dresser 4015	8.31	2.92	1.42	0.356	18.14	10.76	12.60	–	6 – 16.3	0 – 2.03	–	–	Two @ 45KW(AC)
Long Airdox Un-A-Hauler	10.8	3.2	1.83	0.375	28.53***	16.3	–	–	–	0 – 1.95		–	

* Relates to the respective conveyor width and the machine.
**The method and traction is by hydraulic transmission for improved operative control during tramming. In the case of electric shuttle cars, the tramming motors give better low speed control; however, it requires a high degree of maintenance supervision
*** Weight includes battery weight.

So, you can try to see that this shuttle car, they are available of different specifications mainly what is important when you are selecting this machine for a particular mining applications, you should see the dimensions that is your length, width and height, which will have to be compatible with the your coal seams and then, the its Joy technical conditions over there; Joy mining conditions, natural conditions that will dictate your main selections.

Then, the ground clearance depending on that the design, how much exactly below the chassis space should be there because there should not be obstructions in its movement. Then, the

machines weight when it is empty that is what is it is net weight over there and then, your how much is its capacity so that you know the gross weight.

Then, you can see that your natural frequency of vibrations will be ranging within what range and that will be exactly necessary when how your seat will be designed and how you will be having your vibrational impact on it is. So, then the cable reel links that is your where from your getting your main power supply that will be exactly this the thing that if you are to cable reel will be able to accommodate how much this cable.

If your high thick seam, you can have a bigger reel and then, you can have a longer cable, but in you can see here the cable length it can go up to 250-meter, 240-meter, but in average, if you are getting 120, 130-meter, you can think of where will be the location of your that is a main feeder power feeder.

Then, it is capacity it is exactly varies, it can give from about 12-meter cube to it can go up to that is your that 16-17 meter cube. The speed, this was earlier very less nowadays of course, with the variable speed drive, it has got a higher speed up to 6 meter per second can be also achieved. But normally, you will find a 2 to 2.4 because there is a speed restrictions in while working over there and the road conditions are very important.

Then, the conveyor belt which is there, the chain conveyor its speed is also very important because that chain conveyor speed of if this is your how it will be evacuating the material from the that shuttle car to the your this conveyor belt that time is very important because that will be determining the total cycle time of the machines and accordingly, that your phase will have to be managed.

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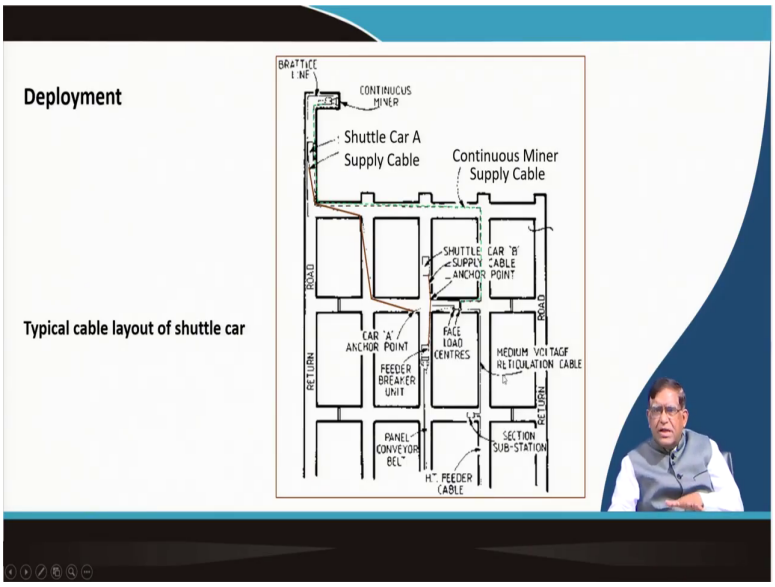

Now, when, how it is deployed? You can see here, suppose your this is a phase on which the continuous miner is working, then it can work with two shuttle car, that shuttle car this you can see that the phase load center, the power supply is coming up to here. Now, from here, this a cable that is your to the cable reel of the shuttle car, it is going over here so, this cable, this shuttle car will be either it will be working over here to this green line is the power cable for the continuous miner.

And then, from here there is one shuttle car is here, say shuttle car B, another shuttle car is A. Now, this shuttle car is getting its power from here and it is going, and it is going up to here. This shuttle car is taking this power cable is going from a point A it is going and then, it is moving over here. So, that means, it will have to the cable from one particular point is working as an anchor point from there, this cable getting reeled and coming back.

So, like that, the continuous miner, when this shuttle is coming over here, this shuttle must be getting loaded and exact that proper scheduling is your while this shuttle car is starting its motion, by that time this shuttle car must come and stand over there for that. Exactly, that scheduling and controlling is the what how you manage a continuous miner and shuttle car system in an underground mine.

So, as a manager, your job will be to see that the specifications that your the capacity and this timing and that the arrangements of this with the your pillar, that route all these things will be there.

So, there are some in South African mines, they have even up to one shuttle car is working with six shuttle car so that there is a high productivity can be done. So, that is then that design, that exactly how the phase is advancing, you can you know that I think all mining engineer these are the your bord and pillar method these pillars.

So, how which pillars and how will be getting developed and how it will work and sometimes, there may be two, three-phases where two continuous miner may be working and then, you will have to make this a arrangement. So, there is a very good things you can study, a simulate such type of situations and you can develop a good animated simulations of this how a continuous miner and shuttle car will be working.

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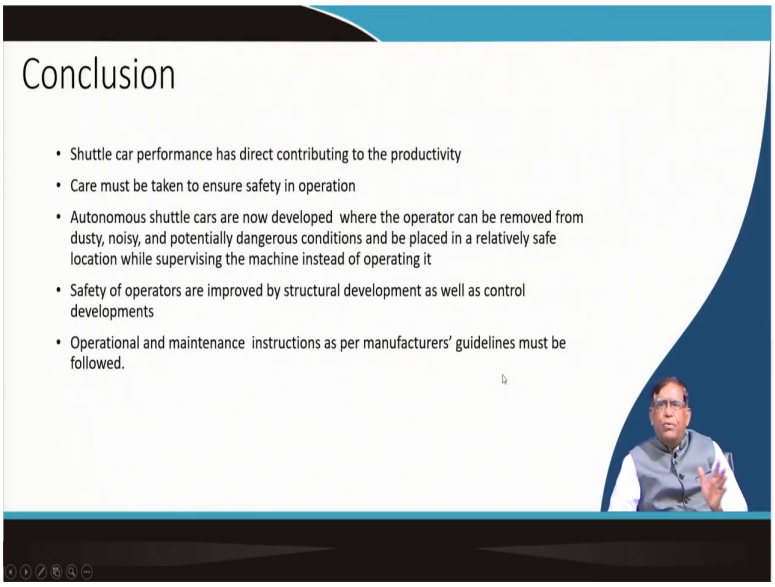

So, to be clear here that, a shuttle car performance has directly contributed to the productivity; care must be taken to ensure your safety in operation. Autonomous shuttle cars are now being developed and then, a man less shuttle car will be there in reality and shuttle car can work if the man-less operations can be done, then it can work even in some of the thin seams, which are normally not mineable.

And the safety of the operators are very important and the structural development as well as the control developments are there. As we discussed in our continuous minor that is the risk assessment, risk identifications will have to follow a procedural step so, that continuous miner and shuttle car need to be studied together as a system of production in the phase.

So, to design the mine phase and to get it productivity so, when we are talking about the more study if you do, its continuous minor and shuttle car, you will have to do how the power cable

will be coming, what is the operating voltage will be operating will be there and how that whole electrical supply system will be following as the phase advances.

So, there are different operational controls are there as you will be studying the method work in underground coal mining in that you know these information's will be applied to really to do a numerical like that for a particular (Refer Time: 30:24) of output or the particular hourly output.

How many, what will be the size of a continuous miner and what will be the size of the shuttle car and in which way they will have to be protect at least, what should be the optimal length of the cable for a shuttle car can be found out. So, that is a lot of industrial engineering study can be done here for this studying the time and motion and also the operational control.

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So, I hope you will be studying that there are a lot of good articles are there in the net as well as the textbooks it is available, this is an old machine and, but still used and some development has taken place in near future, more development will take place.

Thank you very much.