Mining Machinery
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Module - 08
Lecture - 43
Off - highway Trucks

Today we are going to discuss about the Off highway Trucks. So, all of you know that off highway trucks means the trucks which are not allowed to be run over the highways. So, this is in the mining trucks; they are of special purpose trucks which are used on the mine sites and that not on the public roadways. So, these trucks which are of normally of very large capacity.

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So, in this class and maybe the following two classes, we will be discussing about different aspects of this truck, which comprises of a major investment in the surface mining industry. And you should start studying about the trend of development of these machines; this was trucks which were introduced in the mining industry about hundred years ago; today there are lot of developments have taken place.

So, you can see over here that say, how a remotely controlled trucks are now being deployed in Australia. This is no need of an operator to sit over here; this huge capacity truck can be operated remotely controlled. And the capacity of this truck has gone to a very high capacity; here in this figure of course, you are seeing a that is your 183 89.3 liter of diesel per hour consuming truck.

You can see that, amount of energy consumed shows that what could be the size of this trucks; it is it can take a 400 ton that Liebherr a French company their truck. So, in India also now we are producing up to I think 190 tonner trucks can be produced in India as well. So, this is a bigger size machines which are used for different purposes.

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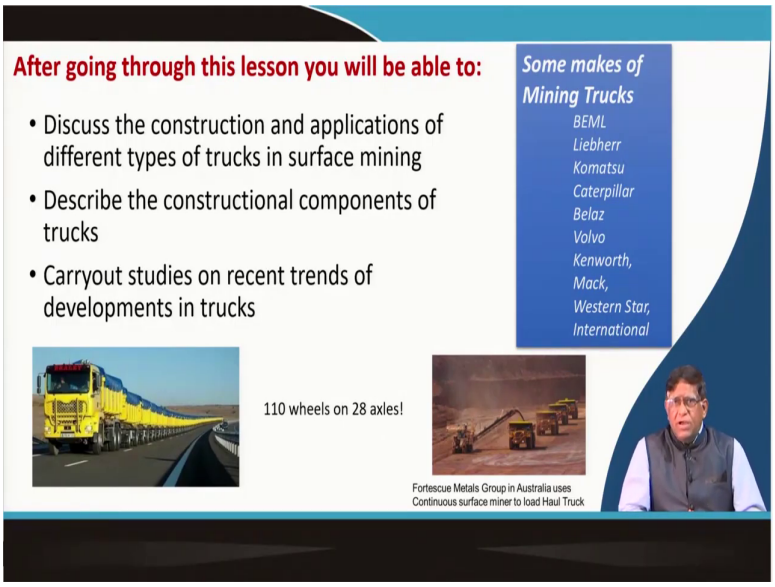

So, after this class, you should be able to discuss the general construction and operation of these mining trucks and also you should be able to tell about the different constructional components and then how what are the different types of trucks used in the mines. And also of course, as a general knowledge and of your interest, I request you please; I introduced to you in the last class that there is a road trains in Australia.

So, here that is your 110 wheels a truck, which is having 110 wheels on 28 axles; can you imagine that such a road trains are working. Particularly in Australia there are different types of such road trains are there, mainly for exporting their farm products like a sheep's, animals that your there for the beef exporters.

They take; because they have got a vast land, where exactly these roads which you are seeing are not used by general public, it is a normally an empty road, which sometimes of a 1000

kilometers long across the country in Australia they are having such type of road trains. And also there is a in Australia that continuous surface miner, that machine we discussed; this continuous surface miner is loading to the trucks.

The trucks are coming one by one and then they can be just spotted and loaded over here, which is very well your IoT control system. As soon as this truck is going to its full load, this conveyor belt will get stopped and then as soon as this conveyor belt get stopped; this that is a just prior to, that it is going to stop this trucks start moving and it comes over here, it will load.

So, this is a system which can be working, some of you can take up a simple model that developing with a model. And this type of system you can design that, how that through IoT you can control the movement that is starting of this trucks; so that means the operator will be given signal. Now, in a when we talk of the automotive vehicles, this can be whole system can be made without any persons by your application of IoT.

So, there is an exercise I have brought this figure for you, so that you can start thinking of how exactly the sequence control of this can be done, what type of data will have to be there, and how you can control from your this office room; say the mine manager if he wishes, he can control the things over there. So, such type of app will be very good for the mining industry tomorrow.

So, you can also while I have; as I have asked you to study the trend of development of trucks; please note down these are the manufacturers who are manufacturing these trucks over the years. So, please try to see and go through their manuals and history and that will be a very good academic exercise to know that, how the systems have developed and where our future is leading to.

So, this is the BEML, Liebherr, Komatsu, Caterpillar, Belaz, Volvo, Kenworth, Mack, Western star, International these are some of the names which are now bog; that likes earlier we used to tell about the Terex, WAPCo those things are there.

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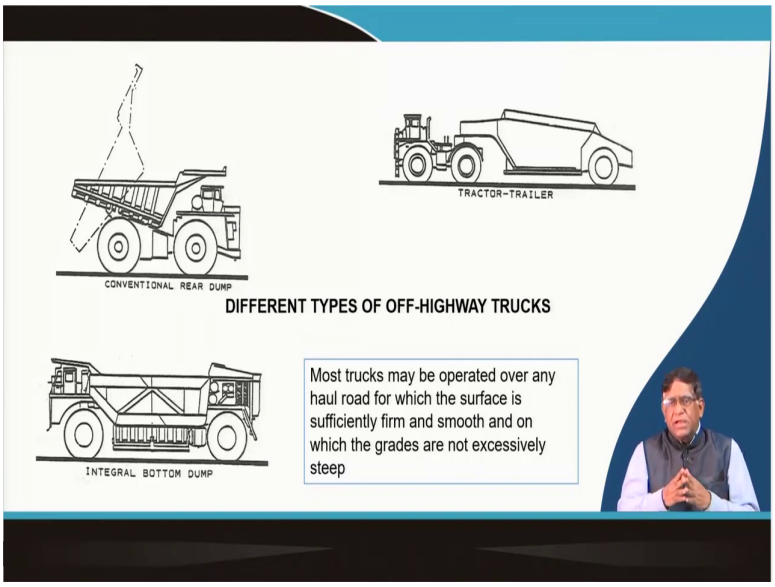

So, as I told you earlier also that we have got the basic two types, that is your rear ditchers and then bottom ditchers, that side ditchers trucks are also there. Even sometimes your road trains that we are telling that, road trains in which there will be say number of truck wagons can be connected together, they can be all made side ditchers.

So, that that is your in the processing plant, we can easily discharge the material. So, side ditchers dump truck with a multi excel that is what is called your as a road train are also being used in Australia, you can study about that.

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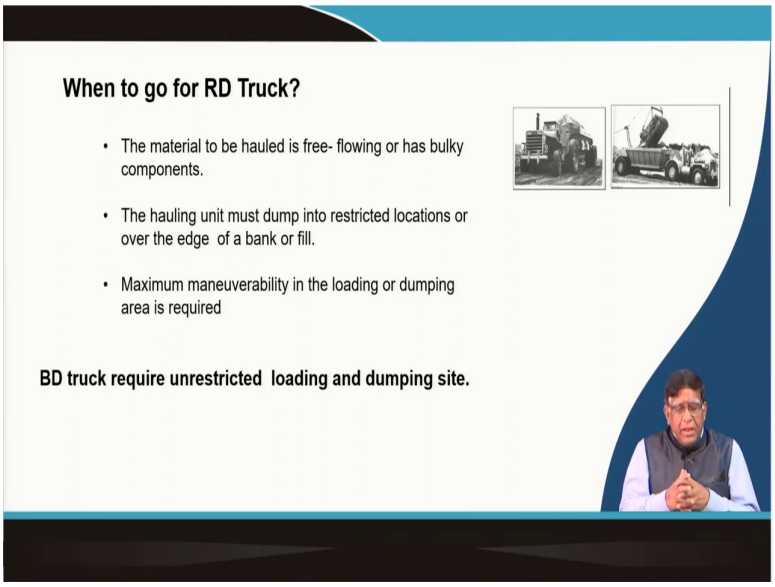

Now, when should we go for a rear ditchers truck, which is the most commonly used in our Indian mines; because here one thing is there, as you can see the material will have to be will have to be a free flowing and bulky material. Then the hauling unit must dump into the restricted locations. So, for example, from the iron ore being mined from the mines, the ROM is taken to the crusher plant.

In the crusher plant, we have got the say main gyratory crushers, at the top side of it there is a grizzly. So, you will have to dump the material on the grizzly. So, it is in a limited space. So, for that purpose it is very good. Similarly this rear ditchers dumper for tip loading for formation of the dump also is very useful.

But this is again in this figure you can see the historically how even in the drag lines were used for bottom ditchers dump trucks; this was this type of systems were used when that the beginning of the technology started in the 40s and 50s.

Now, the maneuverability of the rear ditchers truck is better; because in case of your bottom ditchers dump truck, it will have to be a platform on which it will get open. So, these are the some of these limitations are there. But in a bottom ditchers dump truck, you can easily use for say you want to spread over an area; just like we discussed about the scrapper, this equipment can also that create spreading the material over here.

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So, those are the different advantages and disadvantages of these different type of tracks you must see and you should have a clear visualization of how it will work. Say for example, in this diagram you can see how bottom ditchers dump track, it can be it is given with a

articulations; that means you are having a articulation point, this can exactly maneuver this turning radius, in a small area it can turn and take the material. So, these are the different type of bottom ditchers dump trucks available.

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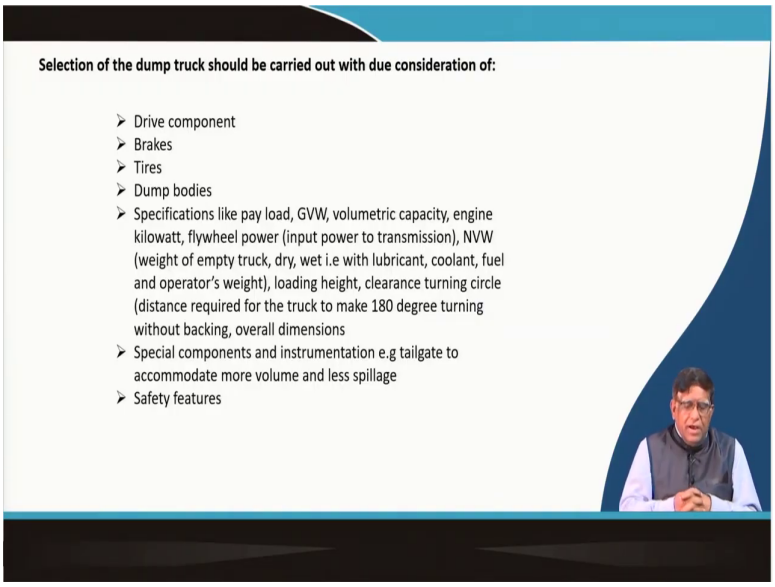

So, whether when you select a dump truck, that is you should take proper considerations of how the truck is made of how what are its main components. Out of these components the most important is the drive component; that means the transmission system. And then the brakes that is a very very important, what type of different type of brakes parking that is your; then regenerative that is the dynamic braking, different brakes are very important.

Tires selection is very very important, dump body; what type of body will be using for what type of material, because that the made, that is the body will be made of what. That is because

the body will be giving to the that is your tire weight that is the self weight of the truck will be depending on the material and the type of design of the body you are making.

And this is a well as a principle, it should be the total empty weight should be as minimum as possible; because then your amount of material which can be carried will be more, that is why your that tire weight should be less. So, that will be determined by the what type of body material and what type of design you have made.

Then this gross vehicle weight this is very very important and also some of the special components like tailgates; then what are the safety features will be added, this will is very important. So, where I have asked you to study the different makes. So, in the different make you find out that, what are the inbuilt safety system in the trucks.

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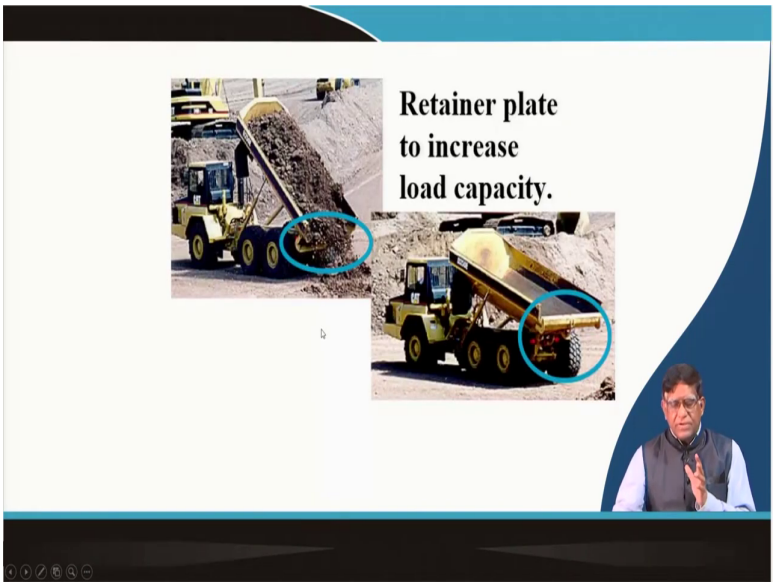

So, here in this ones you can see the that retainer plate; that means when your this material is to be carried, there at the back there is a plate over here, so that during the carriage, the material should not fall down. So, that is why they have a system retainer plate which can be; now this taken separated out as a gate, so that the material while falling.

This you can see that the retainer this plate is brought down here by that, that is exactly just like a gate is getting opened and the material can discharge. So, this is also called the retainer plate can be sometimes a tailgate, this type of systems are there.

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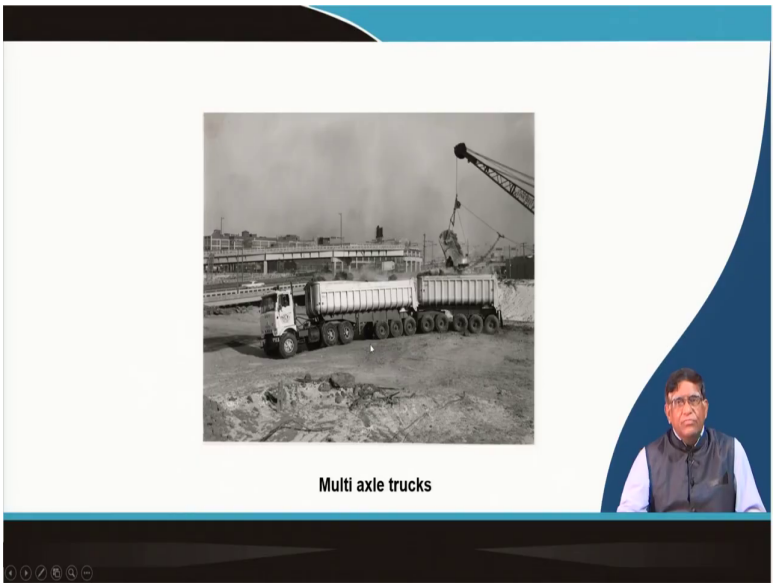

So, now, they sometimes as I telling that multi axle, road trains this was also used in the past; that is a two trucks trolleys are connected together and they are making as a multi axle it is moving.

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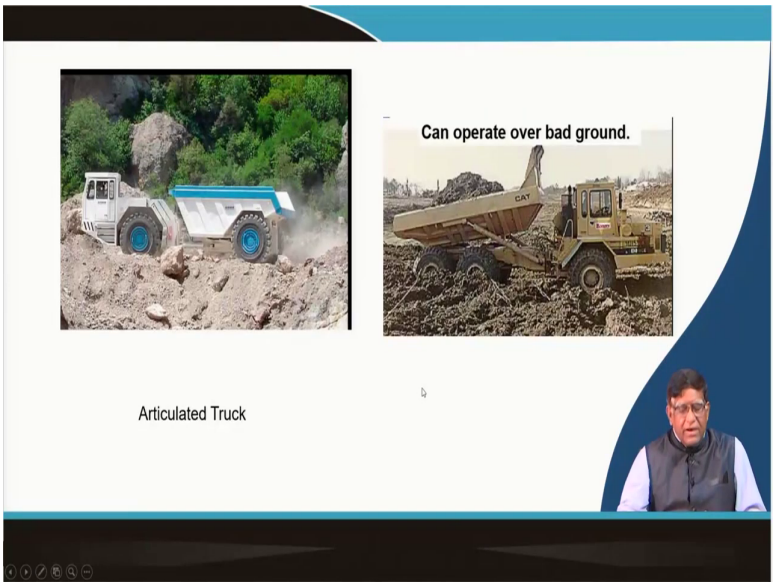

So, there are different way as a articulated truck you know, there is a the front portions it can be separated out, that is two different parts are there. So, these are all articulated truck.

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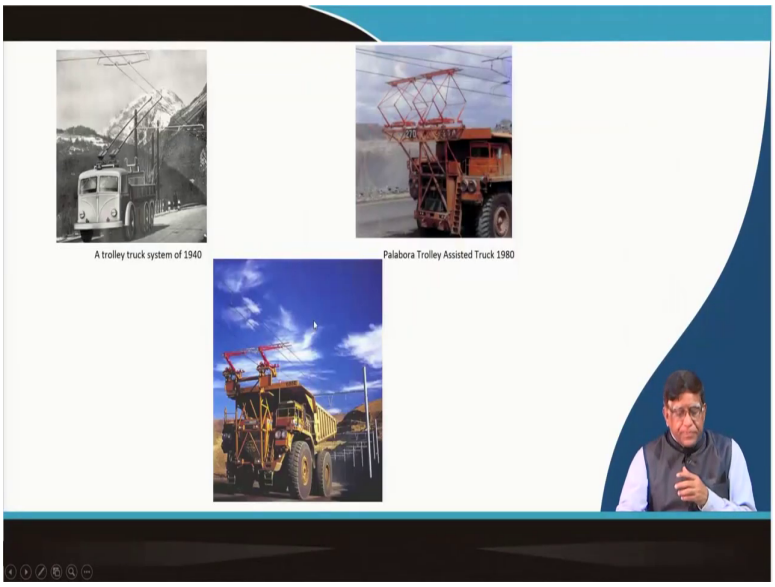

Then another thing is I gave your introduction lectures that, there is a trolley assisted truck; that is in the Palabora mines they are being used here. You can see that there is a overhead electric supply, from there through this (Refer Time: 12:32) it is getting collected to the engine.

So, just like your locomotive, you have got here; this truck engine as soon as is coming to the I at a phase where it is having a gradient or where it is to be that your heavy load is to be supported, there you can have, it get connected over there and you can just that is a engine will not be supplying power, power will be taken from this motor.

So, that is what this all depends on that what type of truck transmission system is there; that means if it is an electric transmissions, these are all wheel motor. That is inside the wheel there is an electric motor and that electric motor gets supply normally from the engine; engine there is a generator run in that is a generator in the truck, the generator supplies the electric current. Earlier it was a DC current were generated and there were DC motors.

Nowadays because of the control is easy; with the recent development of electronics, they have got the AC motors also in the trucks. So, this is called trolley assisted system.

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Now, there is a one thing is there, when you are thinking of deploying these machines; sometimes you will have to also plan the auxiliary facility required, that in a introduction of automobile I told you that, there were some transporter. This type of transporters are used for that; as because the truck is a off highway truck, it cannot be taken to this, sometimes that is

from carrying from one side to another, you may have to use some of the roadside trolleys, they can carry the truck and they can go.

So, these type of systems are also necessary to be known by the mining engineers.

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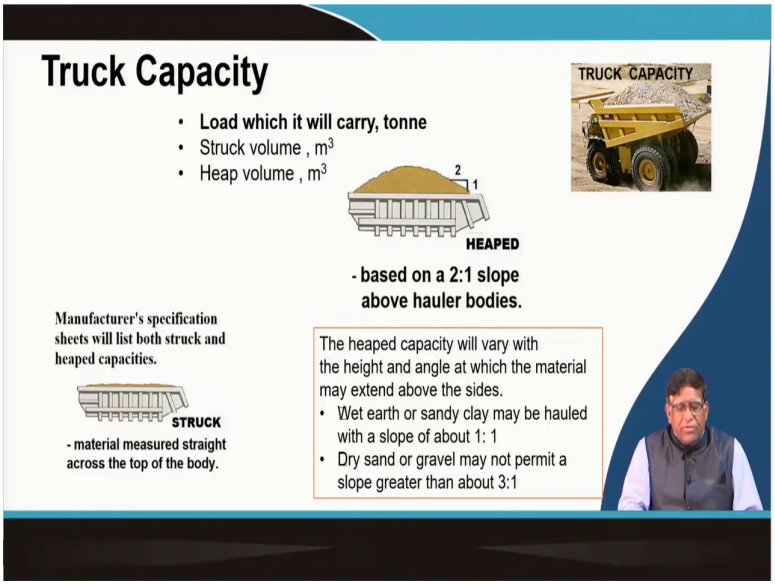

So, one thing what you need to know very well is, what is the truck capacity. Truck capacity as per the standards of the as a standard, society of automobile engineer standard, that is called your struck volume and heap volume. That is your in a heap volume when it is coming over here like this and struck volume means just like that, like your up to the brim.

So, these two types of things are there. Normally, if you are having a 2 is to 1 slope, that will be giving your; that while calculating the volume to be taken by the truck, it will be depending on whether we are going to the heap capacity or this struck capacity. If you carry

sand type of highly flowable material; if you take as a heap capacity on the transport, it may fall down and all, so you will have to maintain with a struck capacity.

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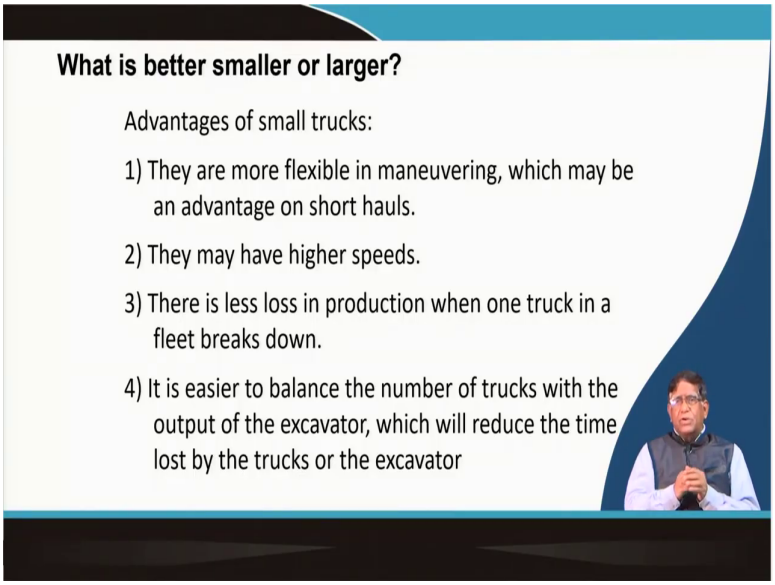

So, this type of information's are necessary, while you will be calculating the total mine productivity; that means how the truck will be utilized, for that purposes this information is necessary. Now, we have seen that we have got truck from 35 toner to 500 ton toner trucks; then what should we go for a very large capacity or should we go for a very small capacity?

Now, what is there? The first thing is if you are having a small capacity, then you are having more number of trucks; if one or two trucks are out of order, not available, then also your mines productions and certain productivity can be maintained. So, that is why they are that they will be; but in case of your loads, if you are having only few and if one is out of order means, your if any breakdown, then it will be exactly affecting your productivity very badly.

So, for that reason, whenever you are using a large capacity truck, you need to see that the reliability and will have to be improved; that means the machine must be available maximum. And that is the overall utilization must be very high for each of the truck; otherwise your whole mine productivity and mine performance will go down.

And also that as because it is a small, it can go to smaller places, it can travel faster and that is why the flexibility of maneuvering it will be advantageous. Moreover the smaller trucks they can move fast and as a result may be sometimes within a limited time you can get more. So, then also the smaller trucks do not require that the very that haul road maintenance cost will be reduced. If a larger truck, then you will have to maintain a proper haul road.

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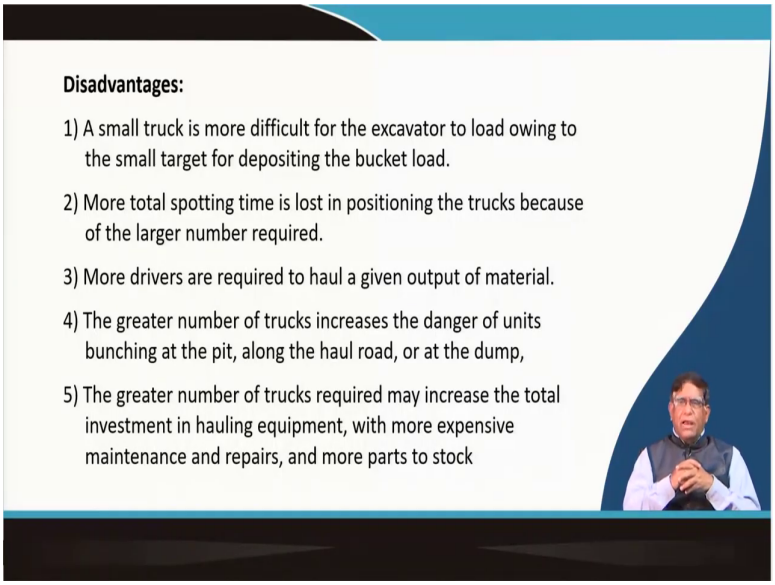

So, those are the pros and cons need to be considered well. But thing is that if you are having a smaller truck, there will be more number of people to be engaged as a driver and then every

persons will be having certain liability. So, with a smaller trucks, your liability goes high. Moreover you can see that in the mining you have got a limited space, limited haul road and there your large number of fleet will be moving.

So, that means when there are more rolling stock in the mines, your chances for accidents will be increasing. So, that is why there is though there is a less skill is required, more number of people are required; but the as a result, the overall things goes in a disadvantage yes. But when you are using a high capacity truck, you will be using very skilled operator, who are generally considered to be more responsible and they keep, upkeepment and all that thing will have to be done very technically.

So, you can maintain a better and decent system in which everything will have to be done very meticulous manner; because if you do not do that, you will be incurring loss. So, that is why you will have to give a more capital investment in other facility development in case of a very large capacity; but at a same time, you will be getting better things. So, these plus and minus will have to be seen and whether this is a which is advantageous, this can come as a your decision question.

And you can mathematically econometrics model can be created for selection of dump trucks, only for the size selections. Please do an exercise to make a develop a mathematical equations; if the problem is given that, if one small coal mine they for their overburden say about 5 million meter cube to be transported from the mine say for 5 kilometer distance.

So, that if you can try to find out what will be the total cost of operations if you are selecting 35 toner dumper or you are selecting 85 toner dumper or 120 toner dumper. So, this type of simple exercise you can do and you can mathematically establish that, which one is better economically.

And then while you are deciding not only the mathematical and on specific quantitative teams; you will have to consider the qualitative and other safety aspects as well. So, please do an exercise on this, so that you can find out which was there.

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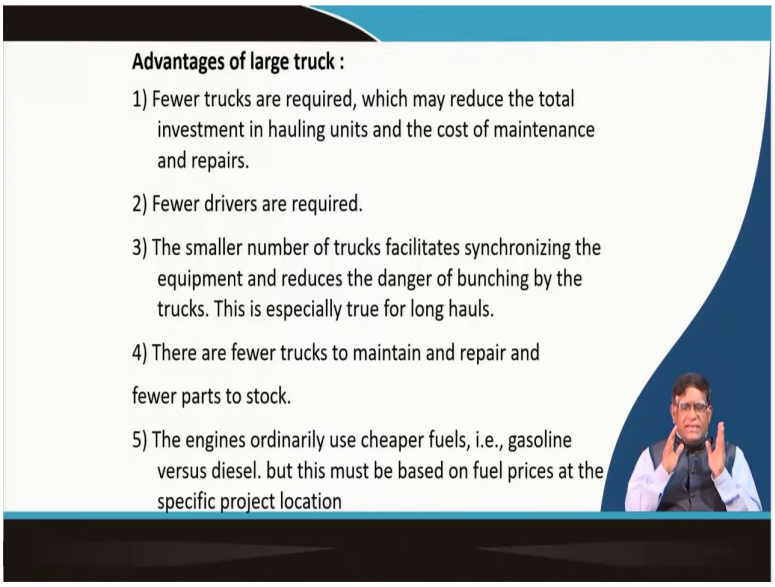

But as I said the large trucks will require fewer truck and then you will have to get less manpower and they say there will be very easy for synchronizing the equipment that is with the other users on the haul roads, as a result your chances of accidents are less. And then as because there is a less number of equipment, you can your maintenance crew they can give a proper attentions and that is why the upkeepment of the fleet could be very easy, ok.

And then your diesel, diesel is a one of the most important things. And that diesel costs that can be a matter of concern while selecting.

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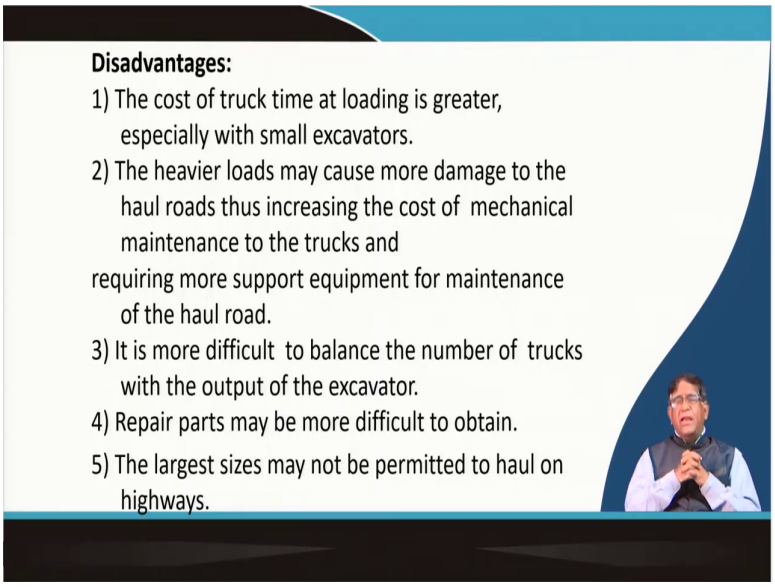

And then disadvantage of this a large scale is, because they are very high capital intensive. And as because their reliability will have to be improved; there will be lot of instrumentations and monitoring will be required, which also will be increasing the cost of your equipment.

So, there is a, then another thing is there, if you cannot go on just only introducing the larger capacity truck; it must be made compatible with the shovel which are being used or the other loading machines which are being used for that. And moreover that if the to maintain it, it will have to have the spare parts. So, this spare parts maintenance also becomes very costly. So, there are pros and cons this you should understand.

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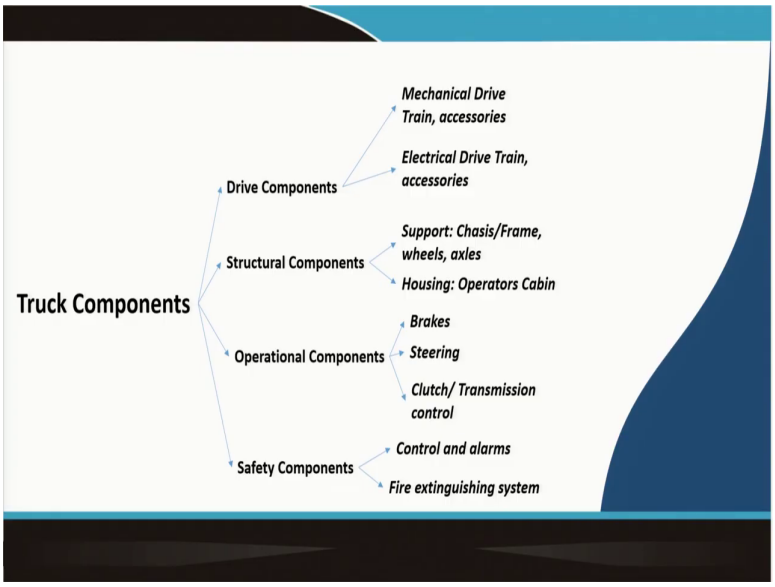

So, now, I think you have got a fair idea about that how the trucks are selected and what type of trucks are to be used in the mines. Now, the second thing which is to be very very important and you should carefully study is the, what are the main components constructional components of trucks.

These constructional components can be considered under this four category; one is that your drive components, which is exactly how these machines will be powered that is wheel will be rotated, that is what is how, that means your it in it talks about the transmission system. Now, how the power will be given at least rotations will be given to the wheel?

And so far there are two systems are available; one is called your mechanical drive, another is your electric drive. Now, that electronic electrical transmissions; that means where the wheels

are being driven by electric motor. And then in case of your mechanical drive, it is exactly given driven by your diesel engines; the prime mover or diesel engine or the electric motor.

But diesel engine is the main, because it is working in your remote sensing; you do not think of that all the places you can get as a trolley systems, where that that is your current will be going, up to face where the machine is being loaded up to there you cannot have a electric line laid. So, that means there should be a diesel system; that means the in the vehicle itself will have to be generate the electricity.

So, there will be a generator will be a main things from where that will be given to a motor. So, that is what is there in a electrical system. In a mechanical system, we will have to have the diesel engine; from the diesel engine how the power is taken. We have discussed about the power transmissions in our machine element class, in our introduction class and today also I will telling you, because this is very very important.

Now, other thing is the structural component. Structural component as you know in other machines we said, they that is your we should say the traveling gear and super trucks are as in so well and all we have said. Here one word you must be hearing very commonly that is called your chassis; as a car or bus or everybody they have got a chassis.

Below the chassis is, chassis is supported on your this on axles which are connected to wheels. So, the main support for this, that is whatever load is coming that load is distributed and going to the ground on the basis of that 4 wheels or 6 wheels or 8 wheels depending on that exactly how you are transmitting the load to the ground.

So, this support system that is a very very, that is your whether the structurally you will have to withstand. Similarly, there will be a housing for the operator that, every truck will be having a operators cabin. So, basically structural component is that main support structures and that body, that is your on which the material will be carried.

This is things, then how the operators cabin will be protected from different loading conditions working interface, that is coming in the design of the structural components. The

operational components; that means while this truck is to be operated in the field, how you will be the driver will be interacting with the engine.

Exactly operational component means, how you exactly you are talking or you are exactly interacting with the machines. So, for that what is there, the operators will be having now it is joystick operated or that will be having yours the steering, there will be the brake pedal; so that means you have got hand and the leg of the operator, they will be controlling the things. So, those are your mainly the brake, steering, clutch and the transmission control.

Now, here this operational component, nowadays it is coming some automated and then some of these operational parameters based on which a brake you will be doing; when you are facing a downgrade you are accelerating, you want to keep a control or sometimes when you see something obstacle, you want to control. But those type of things also nowadays being; that is a with the help of electronic gadgets, things are being done today in the modern trucks.

So, the operational components, they exactly lead to how comfortably the operator can handle with that and how smart is your that machine; that how exactly it gives you the information's about its working, that will be coming in the operational component. Other is the safety component. In the safety component you have got that, how you will be giving the alarm, how you will be controlling the things, and then how exactly the fire extinguishing systems, how it will be incorporated over there.

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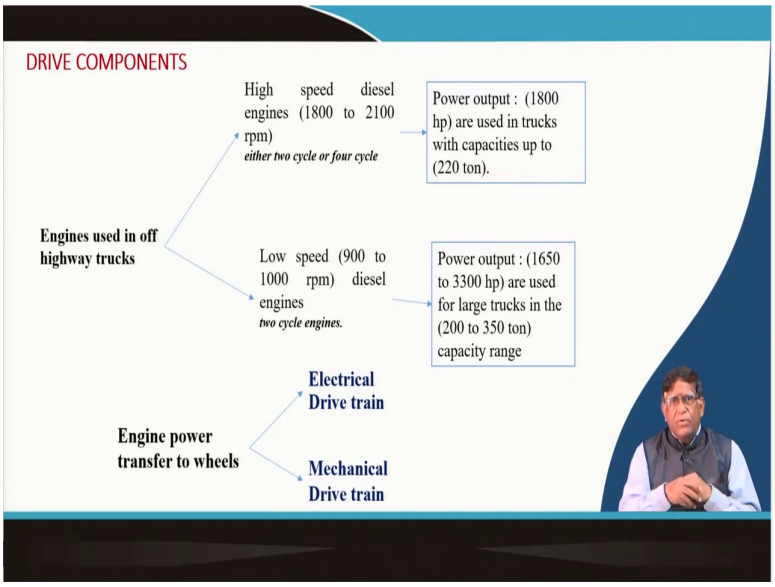

So, in the drive components as we say, that is we have got the that how the power output will be coming from the engines; the modern machines will be of very high power demanding.

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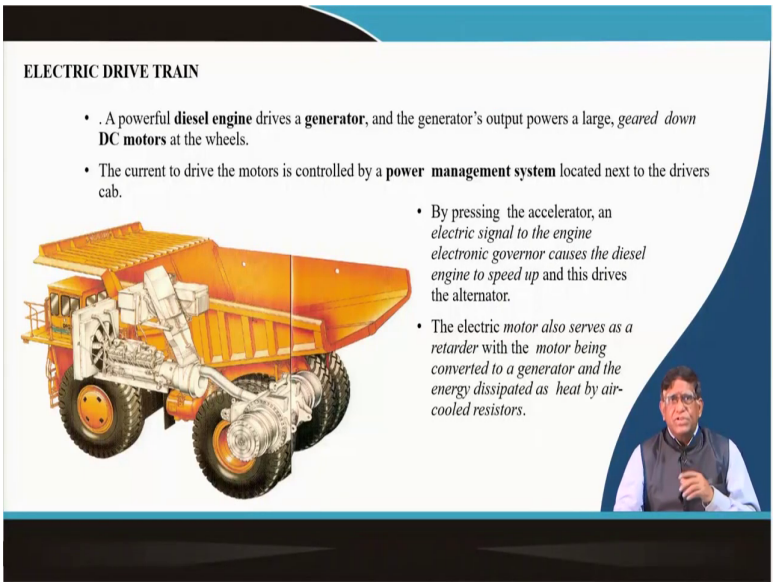

So, this how the train system is there; in a electric drive train you can see here that the from the engine, you are running a generator, from here the power is coming to the wheel motors and then it is working. So, that is the operators exactly he will be having the control from his, this that the speed of this motor.

And then there is a as you know that the steering systems and other they will be working as mechanically. So, it is a electromechanical drive, it is also called electro haul. Normally, there is a high capacity trucks will be done by this.

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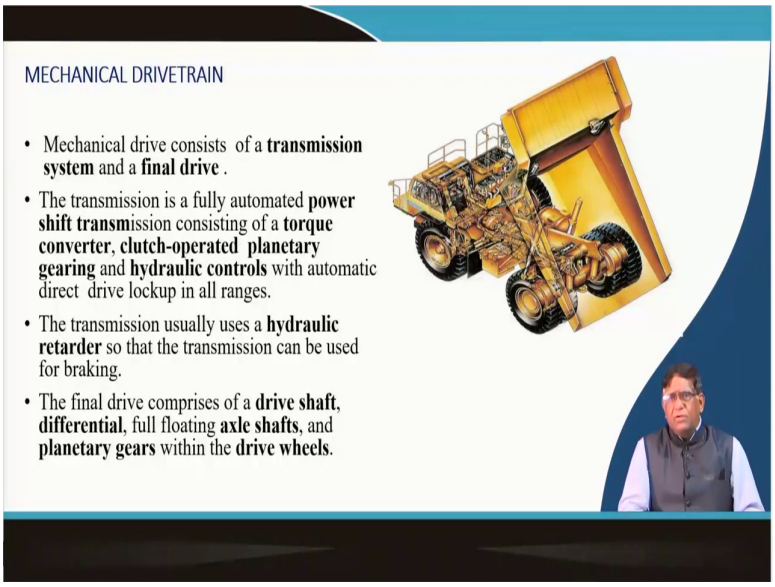

In a mechanical driven of course you know, just like your any transmission system; you have got a final drive will be coming to the wheel via your that is your gearbox you via your you have got the converter or that is torque converter. Or nowadays you are having the power shift transmission; from there it will go to the propeller shaft to the differential and then you will be having this.

And there you will be having a hydraulic retarder, so that the that how the braking during this you need to do a braking, you need to retard, so that retarders will be used.

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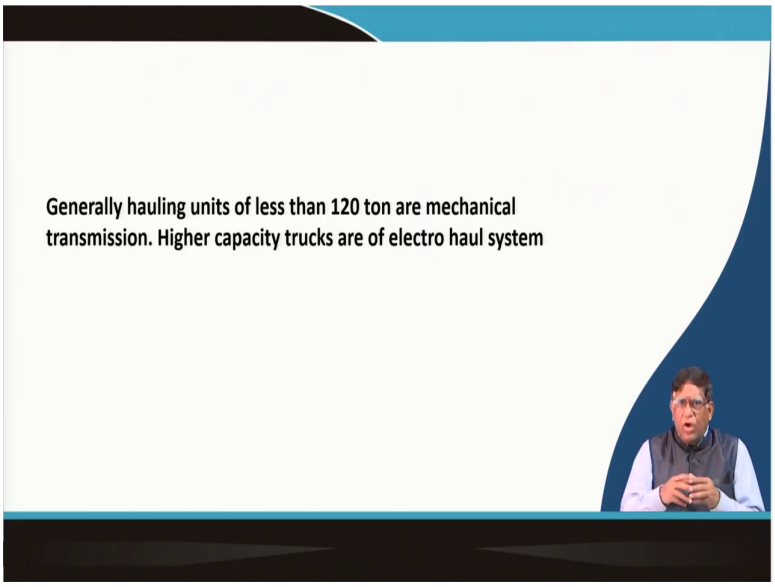

So, generally the units with a 120 ton and above, they are electric electro hydro that is called your electro haul truck, others are mechanical haul.

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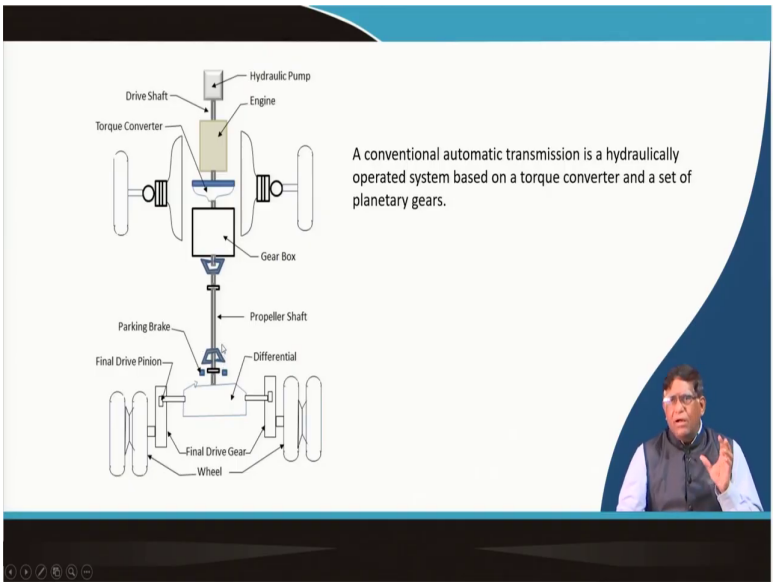

And that system how it works in a truck is known; this is your conventionally a conventional automatic that is your a gearbox, which is a planetary gear planetary gears are taking care of this. And this torque converter, where we are having a fluid coupling arrangement by which you are driving the truck. So, you try to practice this drawing, it will help you to understand what is the basic or the traditional drive system is.

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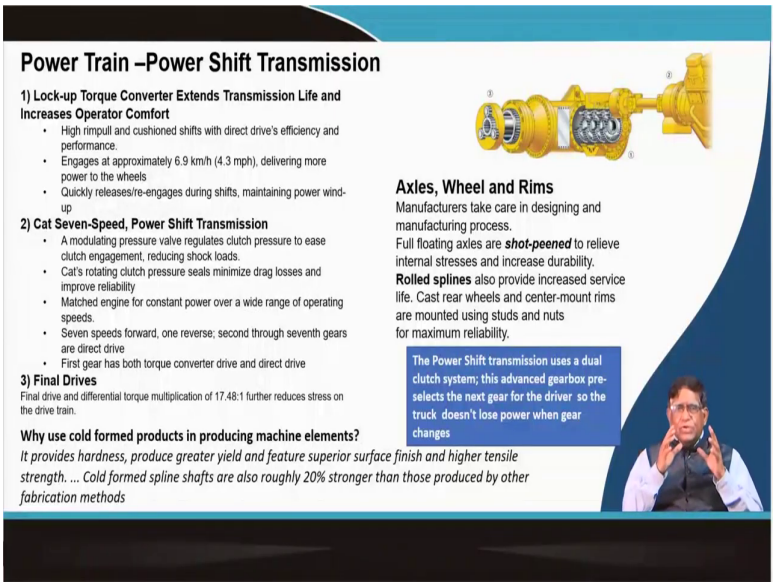

Now, if you go to the operators manual or the leaflets, you can see that what is the present system is coming up. So, that they call a lockup converter, that is your from the engine to this converter, it comes over there and then from there, we are having this a power shift transmission system. From the power shift transmission system, it goes to the final drive where the motors that is are connected together.

So, the another thing is here most important, the modern machines, like caterpillar, then the that even this commercial; their trucks when they manufacture, how the components are being manufactured are very very important. So, some of the terminology you might have studied in your basic engineering, that is called your the axles on which this that will be rotating, they will be getting a different type of loading system.

So, there will be that shot peened; that means they will have to be freed from the internal stresses, for that the manufacturing process that is your caller shot peening, that is your all these are exactly the cold process, in which exactly you will be distressing it. So, that its tensile strength and other capacity get increased.

Similarly, that axles where you will be counting the that is your wheel or the gearbox, you will be splining it; that splines, even their manufacturing also will have to that the type of load they will be getting. If your shaft is connected to your say the this gearbox, that it will have to be splined; that you have studied in our machine elements how the different joints and then the connection connectors work, we talked about the splines.

Now, those splines are also will be a cold rolling process they make it. So, those manufacturing processes are very very important while you are selecting that; because you will know then that what will be the strength of that component, the designers take care of it. So, it is just only for information's you should see about that things. That is your sometimes if it is ask that way, if two manufacturers they have produced the two machines.

And then you have asked, whether that is your spline is a that is your cold roll spline or it is a other heat treated spline; so there you can find out what is the difference of things like that.

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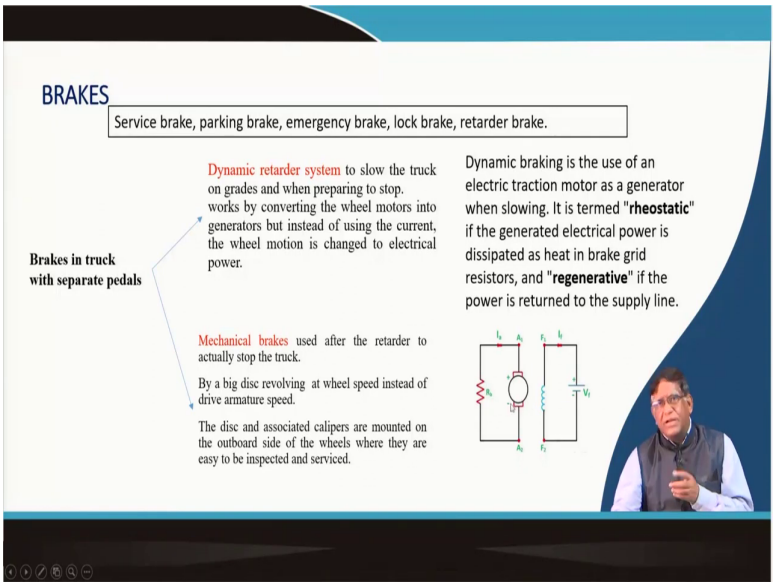

So, then other important thing is the brakes. So, in a mechanical braking, you have seen that is your the different type of say shoe brake, drum brakes those type of brakes are there. But as is an electro haul dump, how the braking will be done? That is exactly though a truck will be having a service brake, parking brake, emergency brake, lock brake, and retarder brake.

So, these different brakes will be say, in case of your that electro haul truck, it will have to be a dynamic retarder system; so that means the motor which is exactly rotating to give the wheel. Now, at the time of, if you are going down the slope; there this it will get accelerated which will be very difficult that, at that time you need not run the motor, because it is automatically wheeling.

At that time, you disconnect the power supply and if you put a resistor there that what will happen; then the motor will become a generator and then it can supply that is to a braking

force it can apply or that can be used also for other lighting and other purposes. Normally, we do not do that; that what we will be doing that, we say it is a rheostatic braking.

In a rheostatic braking, that is you know in a DC motor. If it is a DC motor, in a DC we have got the some shunt DC motor; there at the place if you put a resistance, then what will happen, that is your supply is cut off. So, from you are having a exciter circuit from there the motor is coming and then it will be working as a generator.

And then this speed will be rotating in the opposite directions, means it will start retarding. In case of AC, what will happen? You know that in AC there will be three phase supply will be there. Then if you disconnect one phase and then connect it to, make it to run and only one; then its speed will get reduced. So, these basic electrical things you will have to keep in mind that, how this dynamic retarding system is there.

Say here this is a separately excited DC motors; in that shunt, here normally the supply will be there just like your here you are having in the exciter circuit, there will be one supply. Now, if that one is there, then the current will be flowing in this direction and then this will be working as a motor.

Now, as soon as you have given this resistance; it will become, it will go that current is now going through this, so that it gets start rotating in the opposite direction, mean it becomes a generator and then your the wheel get now this braking actions take place, the retarding action takes place.

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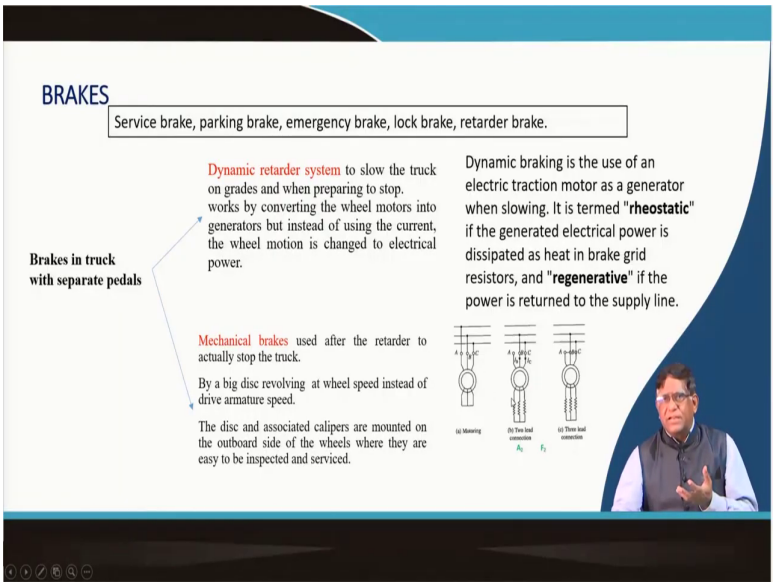

In in AC motors it is like that, you are having this three phase; if you connect disconnect this one, then it will start, exactly it will stop working and then we will get the retarding action. Sometimes this instead of connect disconnecting it like keeping it floated, it can be connected to the second phase. And this is also way how exactly the that your retarding actions in a motor is done. So, this is a wound rotor motor, in that we can do the control of speed like this.

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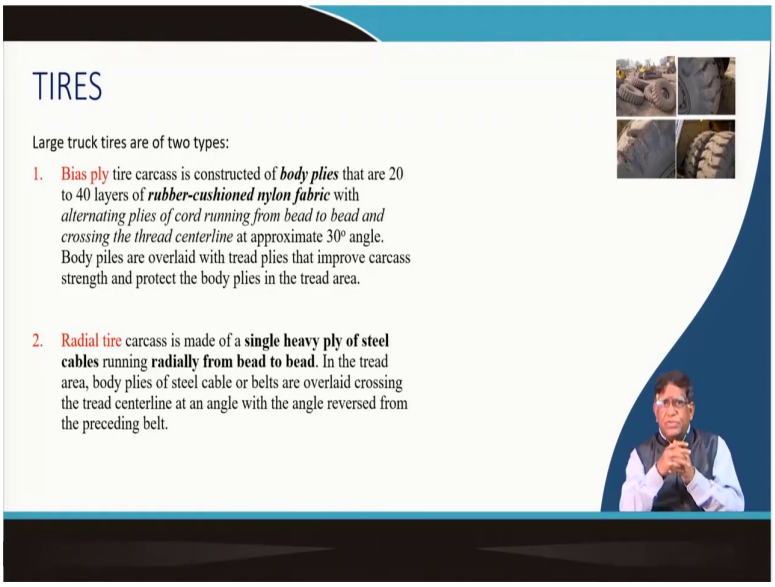

So, the other component which is a tire; tires is the very important things, there are two types of tires which are used. Nowadays of course, everywhere you can see of that radial tire; but the tires is the one of the most cost center, that is it get damaged. But proper use of tires itself can be you can go on studying about the tire, that will be very very important and interesting.

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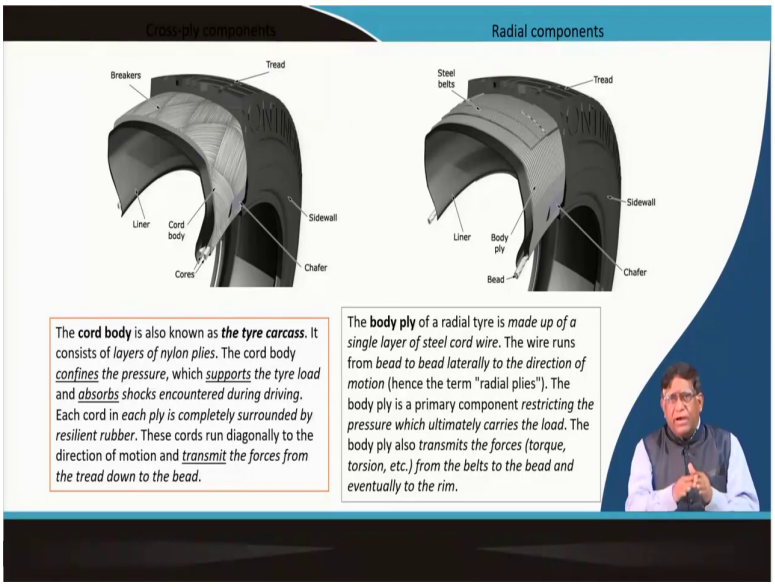

In a bias ply tire, your this inside the cords there at a 60 degree angle; in case of your a radial tire, you can see that how the carcass is made. So, there is a need of studying the tires properly, even how this tire beads are to be there; because they will be affecting how it will be working in a rainy or a slippery road.

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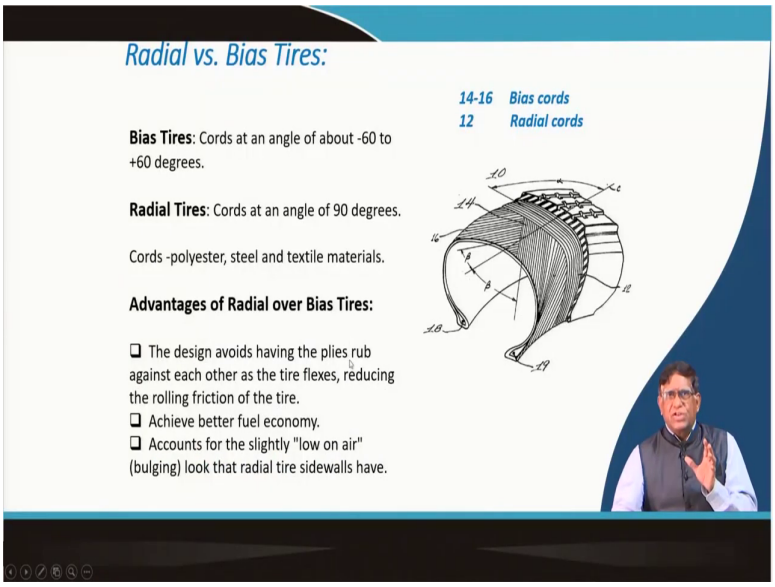

So, I may be in our next class, we will be discussing more on tires; because it is important for the mining engineers to know that highway trucks, trucks tires. We will be discussing about the tires separately in, I will devote one class on tires.

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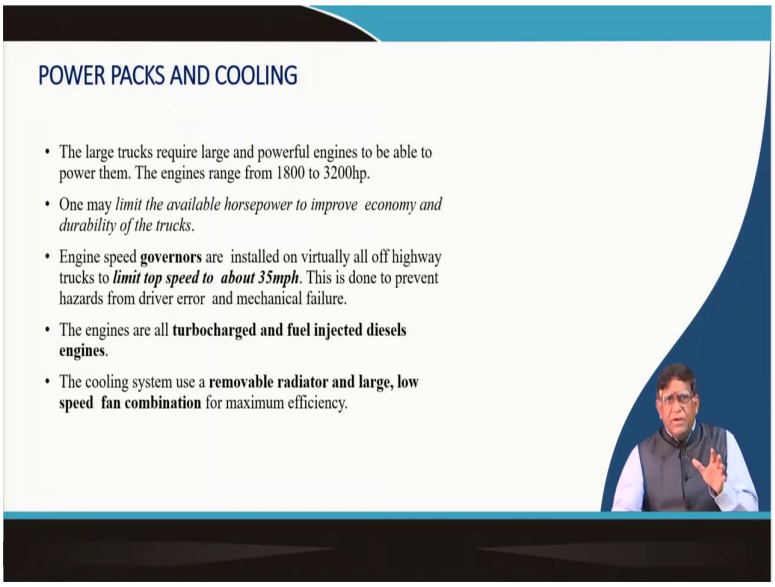

So, then you will have to have that different type of cooling and lubrication system.

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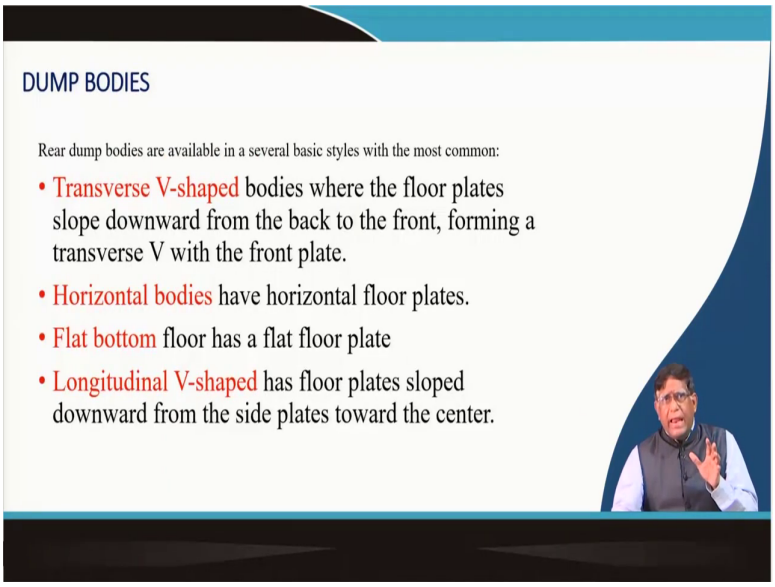

The dump bodies that is also you need to see about; there are transverse V shaped bodies, there are horizontal bodies, there are flat bottom bodies, there are longitudinal V shaped bodies from the different manufacturer of different trucks comes.

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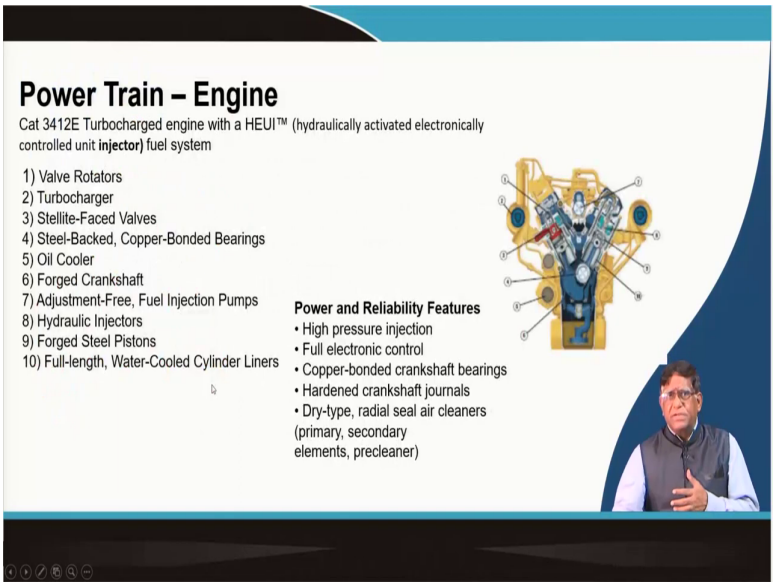

Then the power train of the modern machines, they are coming with a this your HEUI system, that is hydraulically activated electronically controlled injector; they exactly improve the your fuel performance systems.

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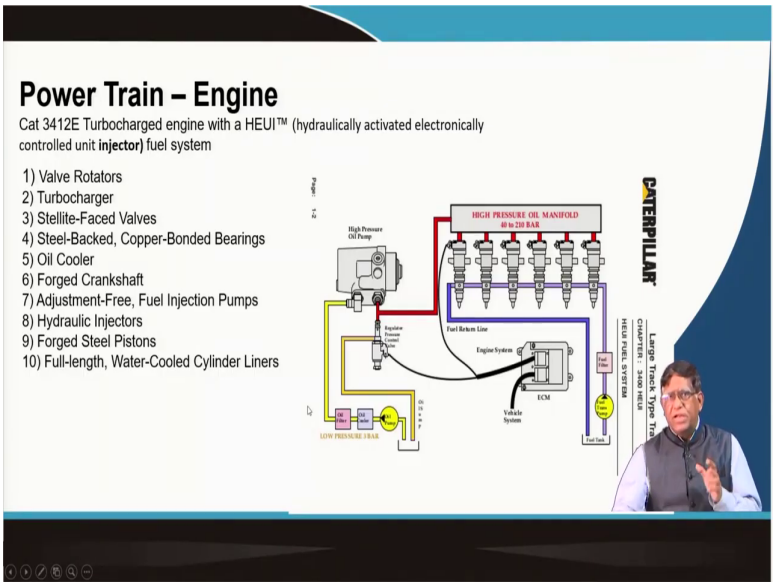

And these modern machines there coming, this HEUI system where you are having the injection; that is your fuel injections to the engine in a very advanced, this is all electronically controlled by properly monitoring of the engine is done.

Caterpillar has done lot of research on it; you can find lot of articles research articles also published by them in a you can in a SME journal society of mechanical engineers, USA their journals are full of such articles, society of automobile engineers.

So, I request you that, if you really want to know that how the mine mechanizations will be empowering our mining industry; these are the things we will have to be studied detail here.

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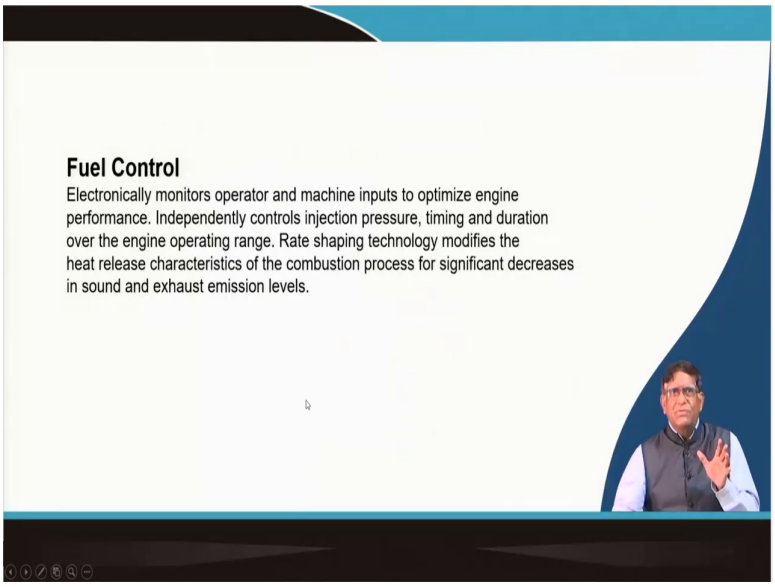

I am just giving you only an introductions that, how a machines will be working.

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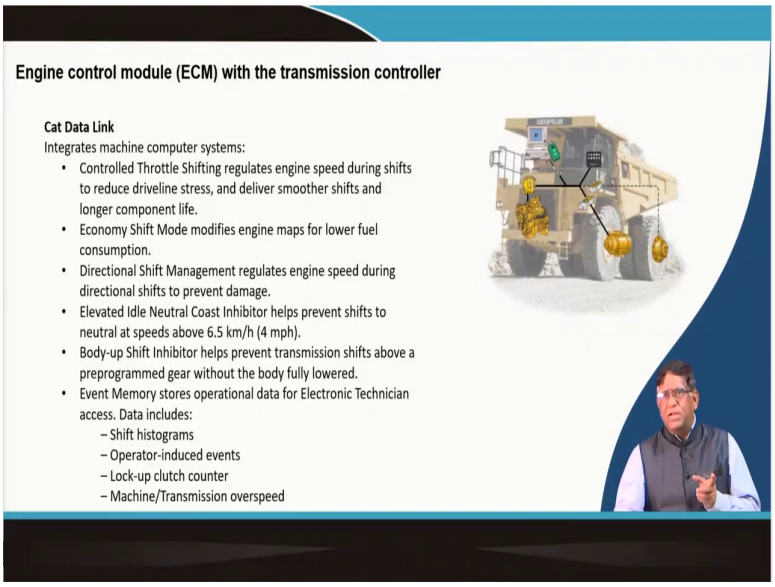

So, a fuel control and also for the electronic control, nowadays which are the unit that exactly getting monitored, and from their data how it is taken over there, and from that data how your whole enunciation the operator is given things. And as I said that because such informed data system and the operator need to be alert and he need to take decisions based on this readings.

So, you can read about it, as because maybe some small exercise you can carry out; because as a mining engineer if you graduate, if you can get a job to be a operator of the dump truck. That it is a good paying money. At the same time as an operator you must know, what are the maintenance, responsibilities of this; how we can exactly improve the capacity utilization of this machine.

So, for that purpose, it is necessary to know; but it is just in one class I cannot introduce you all the things.

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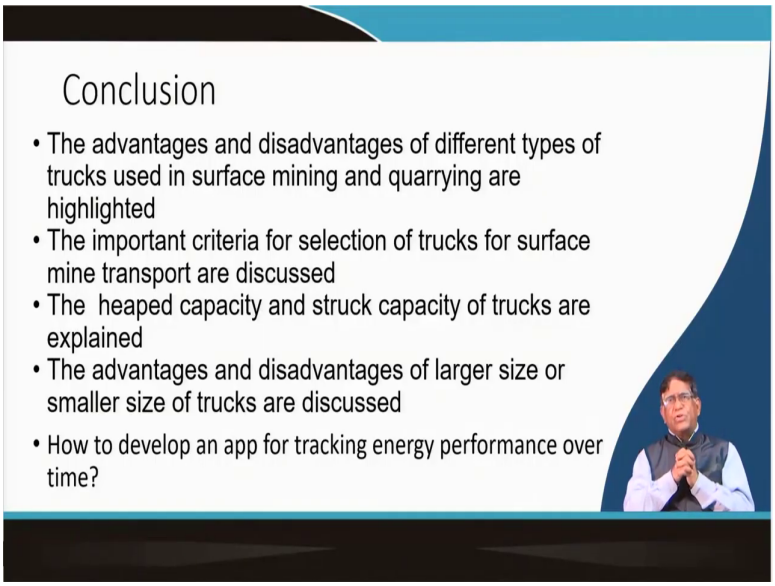

But you please try to understand that say, dump truck is a one unit in a, that is a learning about it properly, you can serve the industry in a bigger way. And for that reason you should also try to understand that, how the this your truck dispatch system is made. Another thing is in a truck, which truck will be reporting to which shovel and then that one is way.

So, that the after all the total movement distance traveled by the truck will have to be optimized, which will give them optimization of your fuel consumptions, your operating cost will be going down. So, there is a lot of work with a industrial engineering have done for the

management of the shovel and dumper fleet together. So, shovel and dumper need to be studied together and it has got a lot of input to it.

So, today what I have you told you about a general introductions of the truck, its advantages and disadvantages of bigger and smaller and also it is what are the main components and what are the recent developments. And also there are lot of opportunity to work with this.

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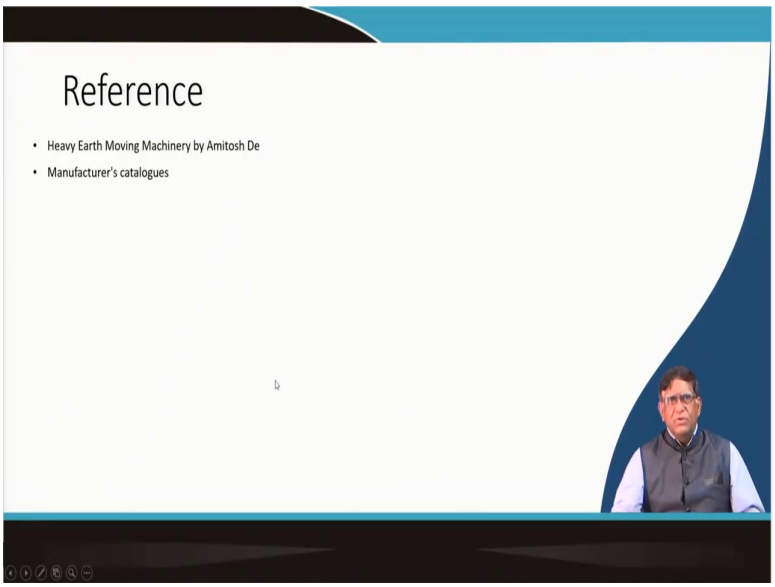

So, you can read that book by Professor Amitosh De on Heavy Earth Moving Machinery; there is a good chapter written on the dump truck. And I hope this will give you a very good learning of this piece of machinery, which is the main workforce in any mines.

Thank you very much.