Bulk Material Transport and Handling Systems
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Lecture – 41
Recent Developments in Truck Transportation

Welcome back students. We are in the discussion of our transportation and bulk material handling. We have talked in the last two classes regarding application of mine trucks and we mentioned about different type of trucks.

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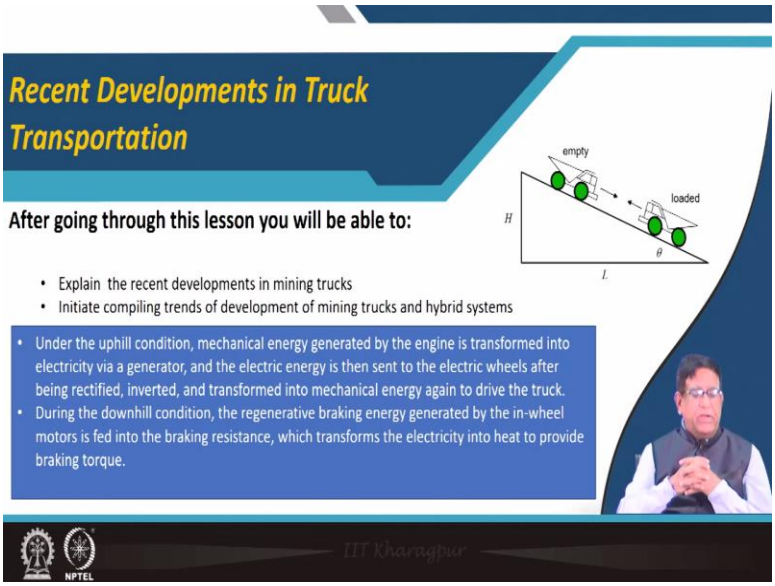

So, today we will be telling about some of the recent developments that are taking place and also after this class you should be able to compile the trends of development and then see that how our future of this truck transportation is leading to and what are the different hybrid systems are now being available on that, but first take a note on the figure here that in mining that what is the special case about unlike the other road transportation.

All surface mines you are having your empty trucks will be going down to the pit and a loaded trucks will be going up the pit. Now this case can be reversed in the case of sometimes in hilltop mining that in some cases in the hilltop mining you will be taking down also with loaded material. However, within the pit there will be always this loaded truck will be coming from the pit bottom to the pit surface.

And even in hilltop mining the pit surface will be at a higher elevation where the excavation is taking place. So, earlier all the time it is being raised powered by your diesel engine and then while going down you are using the same engine power that is giving the braking energy so that the machine did not get overrun with those heavy load. So, there certain developments have taken place over a year so that you should look into this.

But here the main issue is under the uphill condition when it is going up that mechanical energy generated by the engine is transformed into the electricity via a generator and the electric energy is then sent to the electric wheels after being rectified, inverted and transformed into mechanical energy again to drive the truck. So, this is a system that how mechanical and electrical energy conversion is taking place in the truck.

And then you are optimizing the use of energy and during the downhill condition the regenerative braking energy generated by the in-wheel motors is fed into the braking resistance which transforms the electricity into heat to provide braking torque. So, there is two things over here while you are going down now that (()) (03:24) will drive the electrical energy that is your wheel motor this will be working in a generator mode and it will provide the braking energy. So, this systems are nowadays being used.

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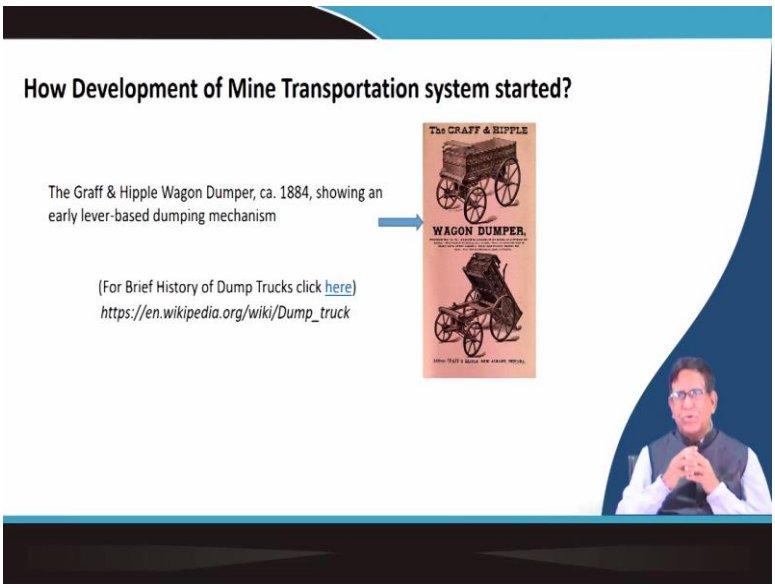

But while coming to this type of stages if we look back into how the total mine transportation started developing if you look this dump truck what you see today the gigantic trucks we have talked about, but by 1884 when its first the concept developed it was a wagon dumper you can see that just like a system where you have just only learning how to trouble it to that

exactly using the liver energy and putting it there so that it can dump. These type of systems were used for clearing garbage cleaning purposes it started working.

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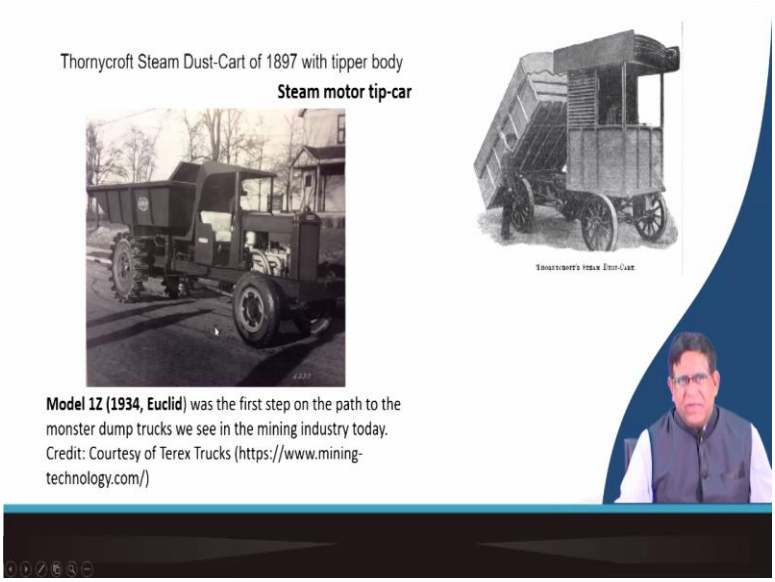

And from there when it started developing it was in 1897 that steam motor tip cars the time it was called a tip car which was developed as you can see in this figure. This was also for this garbage clearing, but in mining this Euclid company they made in 1934 a truck which were having a system of this dump body to do this dump car. Now from that in almost about last 90 years there has been tremendous development.

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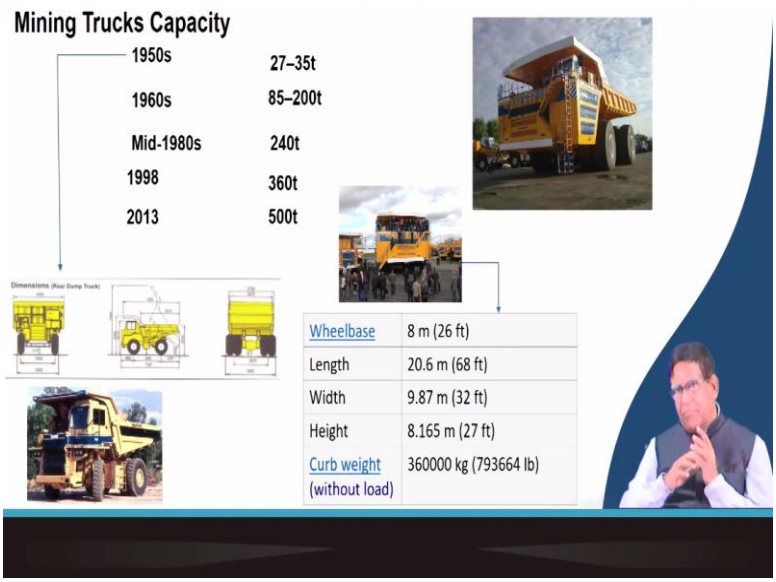

And this development which have taken place in the early 50s there were only 27 to 35 tonner dumper and then while coming into 6 decades this capacity from 35 tonner dumper it came up to 500 tonner dumper which (()) (05:33) machinery manufacturing company. They

have produced this 500 ton dumper. Now, if you see that there in such a big dumper this has the wheelbase has again increase up to 8 meter you know about the wheelbase. Wheelbase is exactly the central line center to center distance of the two axles when there is a two axle trucks are there.

Now this whole land it is over exactly the wheelbase is between the axle distance, but the whole truck this has gone up to 20.6 meter. You can think how big it has gone to and then almost 10 meter width of this truck for carrying and then for this things when it is constructed it is such a huge thing almost 360 ton is its own car weight that is without load and then that means when you are giving a 500 ton weight almost your 860 ton of load of the whole gross vehicle weight is moving over the road. So, this is a tremendous development.

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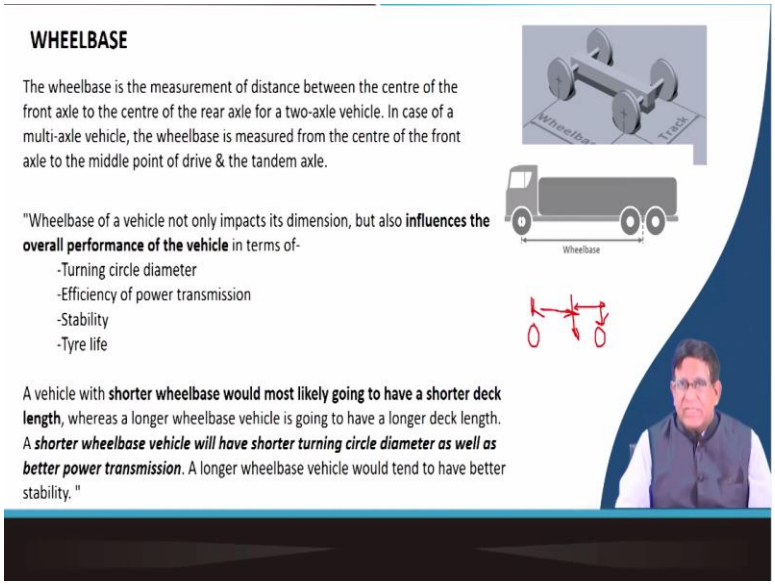

Now, you can see if you go little bit basics of the machines you know wheelbase as we said that this is written between these two axles, but if there are multi axle then the central between these two axles up to here this distance is taken as a wheelbase. Now what happens over here that is exactly in a truck your basic importance or basic attention is it should be stable and on the stability this wheelbase and that your centre of mass.

And then how exactly the moments against this the front axle and rear axle that will have to be balanced. So, that is because if this is the properly designed it may lead to a problem. Now, wheelbase of this vehicle that will be exactly influencing your turning circle diameter then efficiency of the power transmissions, stability and tire life because how it is that how the tire will be interacting with the road.

That means whether it will be going over there you might be having certain experience in bicycle because in the bicycle also we can think of the wheelbase that is from your front wheel and back wheel there are two axle distance. Now, if you suddenly brake on the front brake then what happens your back side comes up that means you are having a additional force when you are giving over to the resistance you are giving on to the front wheel your back comes up.

At that time your front tire will be going and skidding and it will be giving a penetration if you are driving on that is your non metal road that is soft road when you are driving that same thing you can think of that is your if you are that suppose you are having your if you take your wheelbase suppose your this wheelbase is there. Now when your exactly whole load is getting over here.

Now this distance somewhere here will be centre of mass now this now this total load on this and this product and then for this two product that means there that your moment about this centre of mass that should be equal and that is why if you are giving a more load on to the front wheel and then less load over here there will be unbalancing in certain road it will be giving problem.

Now the vehicle with shorter wheelbase would most likely going to have a shorter deck length and whereas a longer wheelbase vehicle it is going to have a longer deck length and as a shorter wheelbase vehicle will have shorter turning circle diameter as well as the better power transmission. A longer wheelbase vehicle would tend to have better stability that is why you might be seeing that sometimes some of the trailer on the road where we were heavy loads are taken in a multi axle things they are normally of the longer size and that is why when we are having your very high capacity trucks their wheelbase is more.

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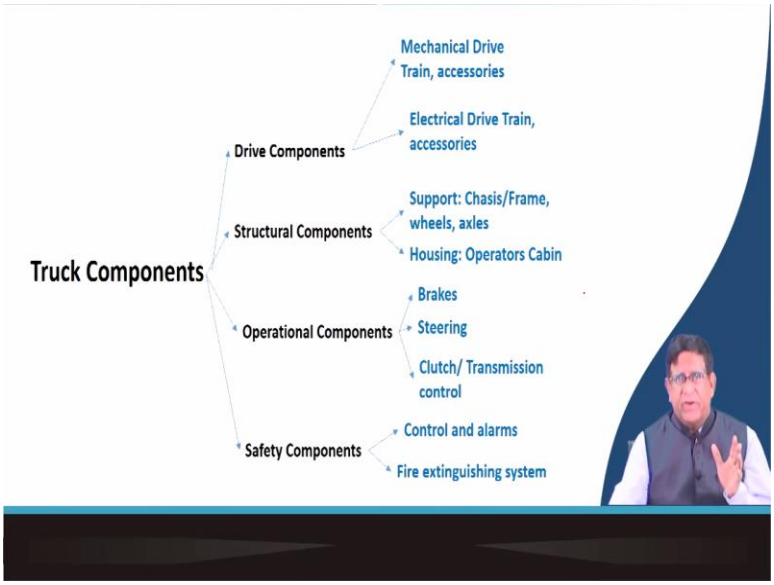

Then more of the basics you can study in the basic engineering purposes or we can do some numerical on it later on if time permits, but let us see what are the different components of the truck. The trucks we have already seen that it has got the drive components, it has got the structural components, it has got the operational components and safety components. Now, when we talk about the trend of development that development over the last four, five decades have done tremendously on this only in recently the control area and your energy power transmission area lot of development have taken place.

The drive components we have got the mechanical drive train and accessories or electrical drive train and accessories. Now, most of the large capacity trucks they are going to have this electric drive and in the last class I told you about how they can take the external electric drive also to the machines the transmission side lot of developments have taken place and the structural component is basically the chasis frame, wheels and axle.

And then housing and operators cabin how they have been arranged and control mainly your operational components or the brakes steering, clutch transmission control that means how they will be working under these things and in that control nowadays because of this with the navigation control with because when it has come to the place of automation then how exactly GPS (()) (12:13) control systems have come.

And other things like with the proximity usage how exactly your different warning system has come, you are using beamer by exactly you know that if any other vehicles. So, you can make a collision cannot be avoided totally those things have got developed recently and the

safety component is that which gives you the control and alarms say, for example, nowadays you cannot because such a very high truck when it is working it cannot see the operator cannot see by the sides or at the back.

Now that is why when it is reversing sometimes even a small car is there they may get accident. Nowadays you are having CCTV type of things central as well as there is now geoinvention arrangements can be made that if anything comes within a particular periphery about the truck there will be a signal and warning systems will be there. So, those type of safety components are there.

Moreover, in the past there were number of accidents that is truck caught fire. Now that fire accidents on such type of large truck is now incident of yesterday because today we have got very good fire extinguishing system and warning system where from the fire can come up and there is a automated protection systems are there. So, this is the things which have got developed.

So, now you will have to start searching and compiling that what are the different trends of development in this area over the years.

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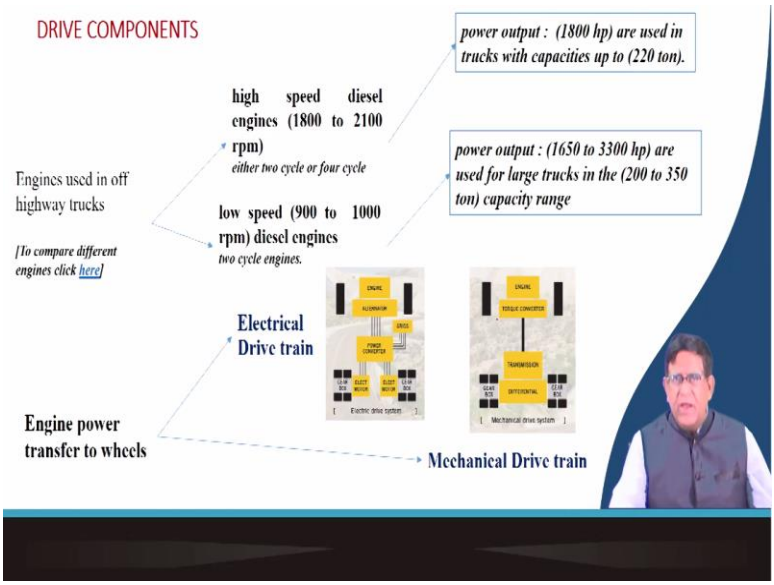

Now when you see about this your developments particularly drive developments there are number of drive components that is your high speed diesel engines and then low speed diesel engine they started coming up and then the power output which is earlier that was from 1,800 hp today there was a very large things then in the case of in the range of 900 to 1,000 rpm we

are getting your 200, 350 tonner trucks they have got different things that is they have got their range up to 3,300 hp engines are being employed today.

But that power it can be a electric drive train in which that you are having the engine, engine is running an alternator from the alternator it is coming to a power converter and it is giving to the grid and from there on the wheel there are the electric motor and then this electric motors are getting you are driving the car, but in case of your mechanical drive train you are having that simple systems with the engine torque converter transmission, differential and then with the final drive you are having this things.

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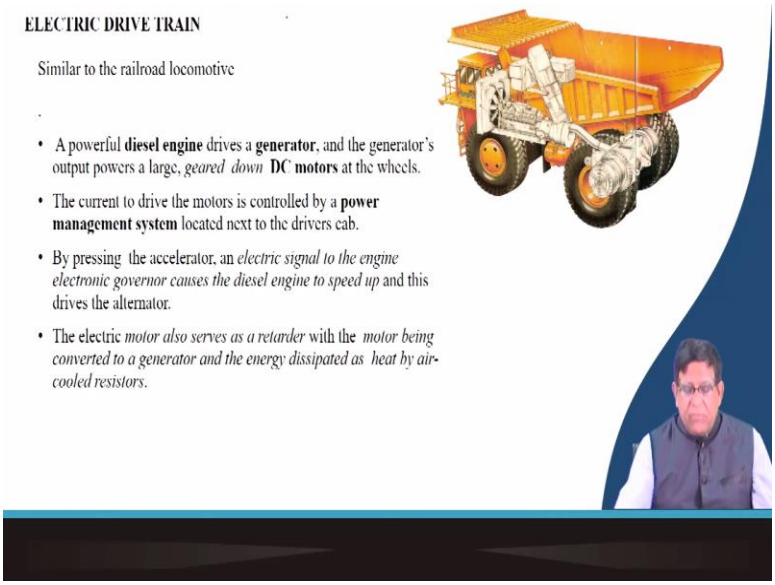

So, that in a electric drive system we talked also earlier that how a powerful diesel engine drives a generator and generators output powers a large geared down DC motors and which are mounted on the wheels and the current to drive the motor is controlled by a power management system that is electronic control unit has become now an important part in a dumper operations.

Now by pressing the accelerator and electric signal to the engine electronic governor that causes the diesel engine to speed up and this drives the alternator. So, depending on the power requirement if we are going uphill at that time more generations can be done by that means your intelligent smart systems can monitor that and accordingly give the signal so that your generator will be generating more power.

The electric motor also serve as a retarder with the motor being converted to a generator and energy dissipated at heat by air cool resistors.

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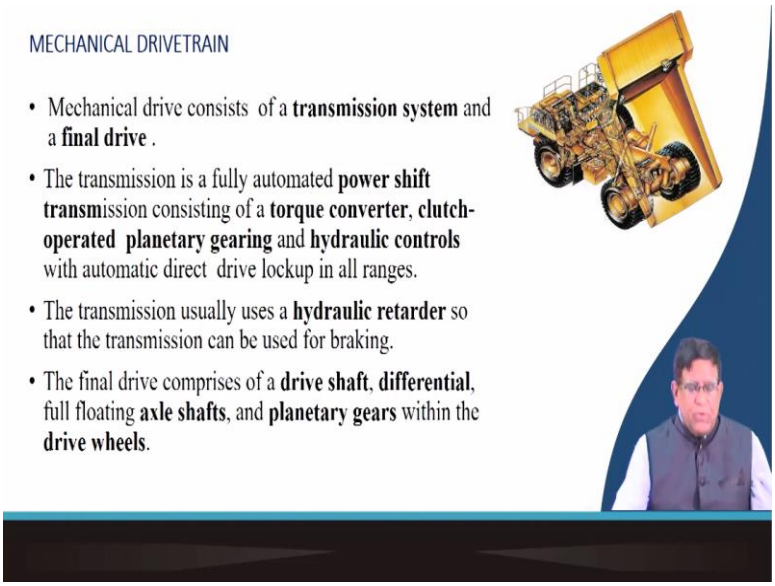

These are the systems which have already being introduced compared to the earlier that what was the mechanical drive systems in which the transmission systems were going up to the final drive at the wheel. The transmission was fully automated power shift transmission consisting of a torque converter, clutch operated planetary gear system, a hydraulic controls and automated direct drive lock up in all ranges.

Here comes now things you will have to know what exactly this transmission systems are if you see that the 35 tonner truck when it was there in 1950s, 1960s (()) (17:07) transmission that hydrostatic transmissions that came and slowly there were lot of developments over here and today we are having those automatic transmission. The transmission usually uses this hydraulic retarder so that the transmission can be used for braking that is the same principles that is used that is at the time of going downhill that your energy will be applied in the braking so that it does not get over speeded.

The final drive comprises of the drive shaft, differential, full floating axle shafts and planetary gears within the drive wheels. Now, this words that need to be individually, separately learned and for that we will have to take some little bit of different exercise. Now, first let us see about what happens here.

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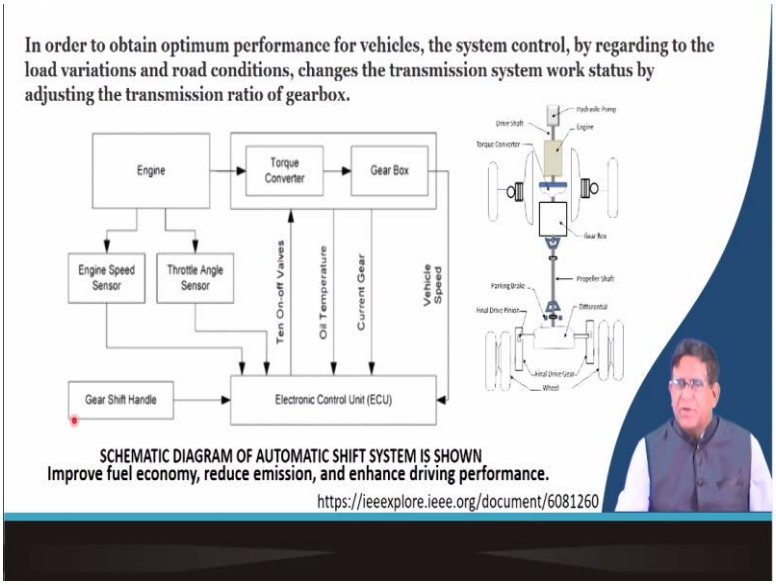

As you can see in this diagram that is your how the mechanical power transmission is taking place. In this you can see here if you see that this is the engine that engine has got this drive shaft. One is giving to power to the pump the other is giving to this torque converter. Now from this torque converter it is going to this gear box, from the gear box output shaft it is giving it to the propeller shaft through there will be a universal coupling.

Then it is going to the differential and from that differential there also you have the parking brake in the trucks. So, that when sometimes parking on an inclined slope and all and from that differential it goes to the final drive gear and from the final drive gear it goes to the wheel, but this system in order to obtain your optimum performance for vehicle the system control by regarding to the load variations and conditions now we have got very improved version of it by which your whole transmission and the gear box can be controlled.

If you can see over here again what is there from the engine and a torque converter and a gear box that main portions of here they have got now different type of sensors they need to be monitored that is the result of all mechatronics development which gives your mainly the engine speed sensors and the throttle angle sensors and they give the truck converter there are number of these are valves and their oil temperatures their current gear which gear has been selected.

And then at what speed the vehicle is there this whole units are now the sensor based and their results the signals come to the electronic control unit and they give exactly what the gear shift will have to be there. So, that means depending on when you are going up that means

you are requiring now more energy, more torque is required so at that time that at what speed it will go that will be decided by this unit.

And then accordingly you will be doing the gear shift that is you will have to put that thing. So, these systems are now being introduced.

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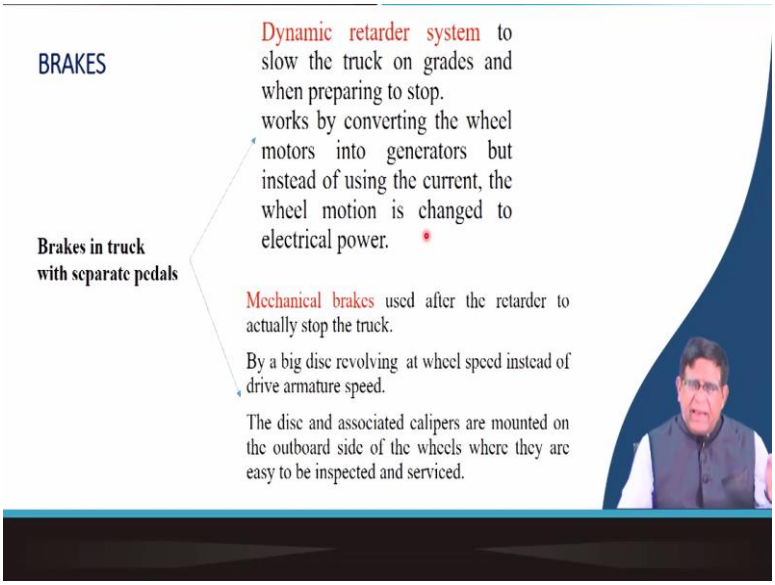

Now, as things simple things you can recapitulate whatever you have learn in your earlier classes regarding the different type of brakes that in a truck you have got a dynamic retarder system to slow the truck on the grades and when preparing to stop the works by converting the wheel motor into generator, but instead of using the current the wheel motion is changed into electric power.

So, that is the basic concept in your dynamic retarder system and the mechanical grip brake you have seen that mainly the discs brakes are used and where your brake is hydraulically operated when you will be pressing the operator pedals at the time the hydraulic (()) (21:29) and it will excavate the disc or drum and that will be exactly retarding or giving additional resistance to the wheel so that it will stop.

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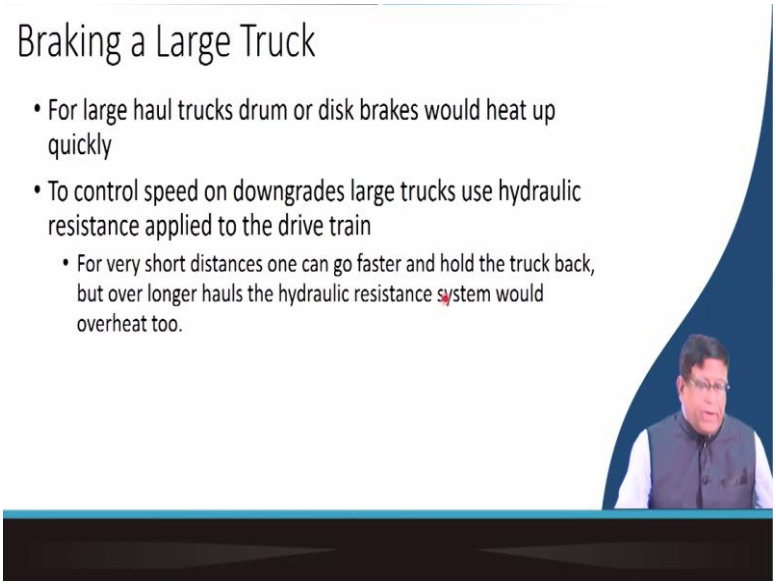

So, that large truck for large haul trucks drum or disc brakes would heat up quickly that is why to control speed on downgrades large trucks use hydraulic resistance applied to the drive train. So, that is for very short distance one can go faster hold the truck back, but over a longer hauls the hydraulic resistance system brake that will also get overheat. So, that is why a proper cooling system and then because when a total vehicle weight of 700 ton when it is going over there.

And there you are applying a resistance force only a disc or a drum that huge force and it will be giving lot of frictional resistance. So, the selection of the material of which it will be made and things that will be very important things that will have to be learned.

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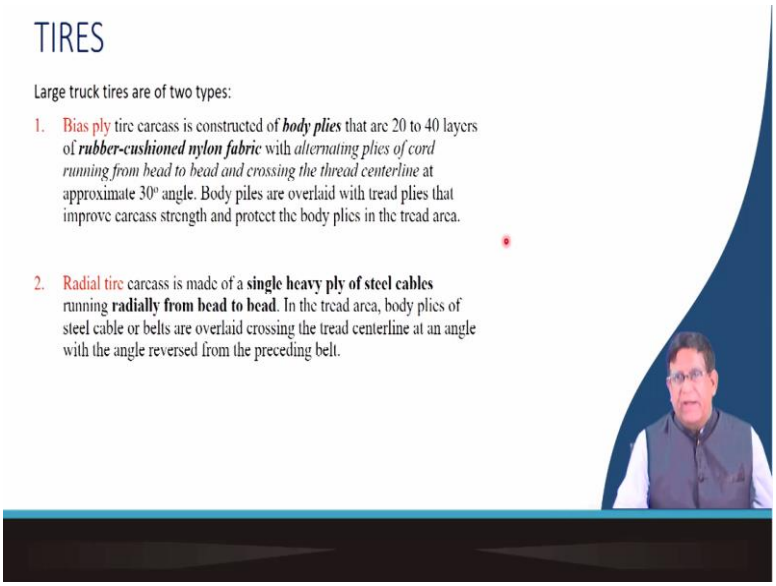

Similarly you will be learning about that what are the different type of tires is used you known earlier these were all bias ply tires which are now using radial tires. So, that is your in a bias ply tire the carcass is constructed of body piles of 20 to 40 layers of them and rubber cushioned nylon fabrics were used, but in radial tire their carcass is made of single heavy ply of steel cables.

And that is why they are more durable and in the tread area, the body plies of the steel cables belts are overlaid crossing the tread and control in this how this tire what type of tire we will be selecting is another issue than all the tire manufacturing that is when you are doing a very large scale tire it is again a issue of selecting the right material rubber material for the tire because when the tire with such a heavy load when it is rolling the road and tire interactions.

And the road you know it is already the rolling resistance may be very high and then frictional resistance also may be high under that condition with such a heavy load it will be again subjected where (()) (23:59) can be taking place. So, the large capacity tires how they have developed and what are their present status that is also another area of monitoring the trend of development and reporting it.

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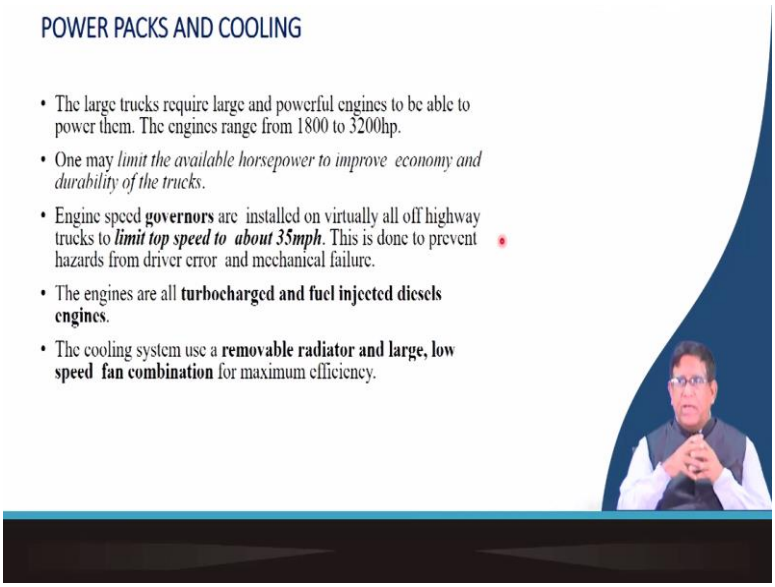

So, the power packs and the cooling that in such a big trucks how the cooling systems are being managed and then as it is a very high capacity engines there are can be your 12 cylinder, 16 cylinder, 20 cylinder your diesel engines will be used then you can easily think of that how much will be exhaust gases will be coming. Now that exhaust gases and that is why that engine what type of engine we will be using that depends on there the operating

systems, the naturally aspirated engines which you are using your ordinary car will not be working.

You require to burn that much of your diesel you require more oxygen, more air now that much air by natural aspirations of the engine will not take place. So, that is why in all these large capacity trucks they will be either turbocharged or supercharged. Turbocharged means from where the exhaust gases will be coming out from the engine that exhaust gas will be driving a blower by which the air will be forced into the cylinder block.

When it is exactly that in the compression cycle your exhaust air also that is will be driving a blower fresh air will be pushed into it so that the combustion is proper. In a supercharged engines for this they will be doing exactly that some power from your crankshaft will be taken and then from there they will be running a blower and then the air will be put into the cylinder box so that your aspirations that is air supply to the cylinder block of the engine is good.

Now, the other thing is that the cooling because when you are having very high power 3,200 hp engines when it will be operating there will be lot of this heat energy will be generated so their cooling systems also have got lot of developments over the years. So, you will have to see.

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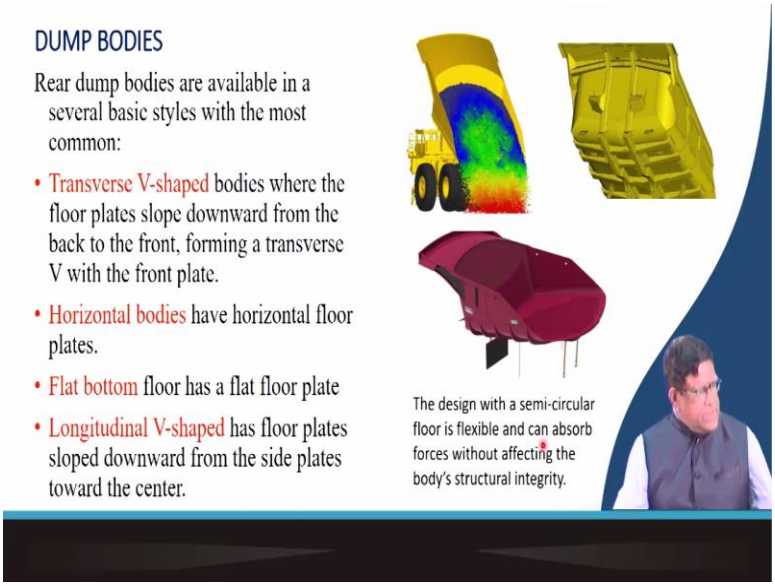

Then the other developments which have taken place in the dump bodies, the dump truck where you are carrying about either 50 ton to 500 ton the dump body need to be also properly

designed. There are certain manufacturers some specialist some designer they are doing how best this could be there, the constraint is it should be having a light weight it should be having a better life.

And when it is raised the material should get properly evacuated the material should not get stick to it and then you may be working some time very sticky type of material that also should not stick and at the same time if you when you are putting it over there the driver or the operator cabin if it is there they should not get disturbed or there should not be any rock falling on them.

So, all these things are protected, but there are different type of bodies like transverse v shaped bodies, horizontal bodies, flat bottom bodies, longitudinal v shaped bodies and also some of these things where we are having this is a wave sided based, there is a circular type of bottom and also this is a semi circular bottom pipe at the back side that the material should not get spilled that is why it is v shaped is there.

And when it is raised the material should get just like a (()) (28:02) affect material will go, but this development from these different type of bodies this cannot be a part that is here all your operators cabin and all will be below here so that any rock boulder it cannot be giving distance this development.

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But later this development has come with your automated that is now caterpillar. They started with this your automated truck that means you can see here in this truck there is no operators cabin. Now this is fully automatic systems have come up.

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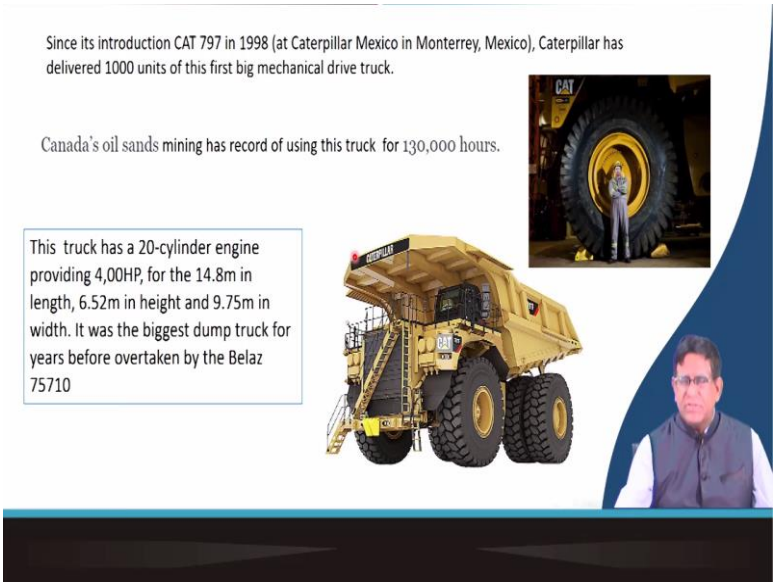

And at such a large when you got the very large system this caterpillar they are leading the industry from 1998 the caterpillar particularly this model 797 model which introduced in 98 now the worldwide there are more than 10,000 such type of trucks are operating in various mines. Now this engines where there are larger capacity the 797 F which has got now 20 cylinder engines are giving your 400 hp such a big machines are working, but this is getting now a manless.

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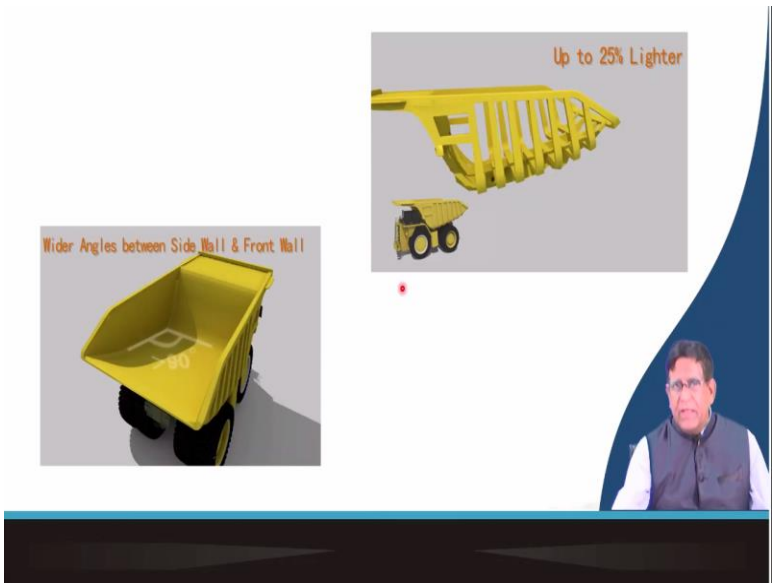

And for that in that they have developed different type of your body also developed so that the better clearance could be done.

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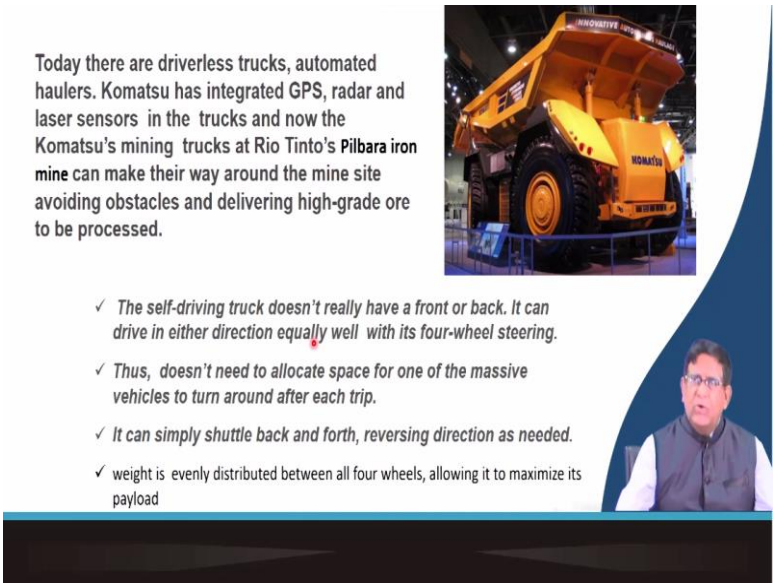

But when they are bringing to this automated that is automated came with this whether it will be fully automated that means nothing is there no you can do at a 5 kilometer or 10 kilometer away from the mine and you can thus monitor there or sometimes it could be just a remote control that means the some operator will be there outside away from there and then some of the basic wherever needed they can control the vehicle also from there.

Now Komatsu they integrated this GPS radar and laser sensors in the trucks and now this Rio Tinto they have deployed such machines in their mines similarly BHP Billiton that they have also used some of the modern developments in this self driving that is no operator is required, their steering, their braking, their automatic control the positioning it for getting the load from the shovel everything is programmed and they can do it by operations assumptions.

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Now there is also a better of all putting the sensors over here each and everything and then they move on the track and that sensors are activated where how the stresses are developing this can be seen at a remote places from automatically all the signals, all the information collected by their automatic control unit. It will be transmitting the information and from a distance you can see.

Now the vehicle can move both the ways so there is this is coming over here straight from this side it will be dumping over here and it will go directly and then after dumping this body will be coming down and it will start moving away from the dump yard to the loading yard. So, normally other type of truck they will have to take a turn, their position, then put it over there.

So, the cycle time increase now when your cycle time is now reduced means that the fleet size, number of trucks required will be reduced means huge savings over there whatever investment they are making on this they are eliminating the operators and also increasing the productiveness and because of this over the last 5 years this has become tremendously popular.

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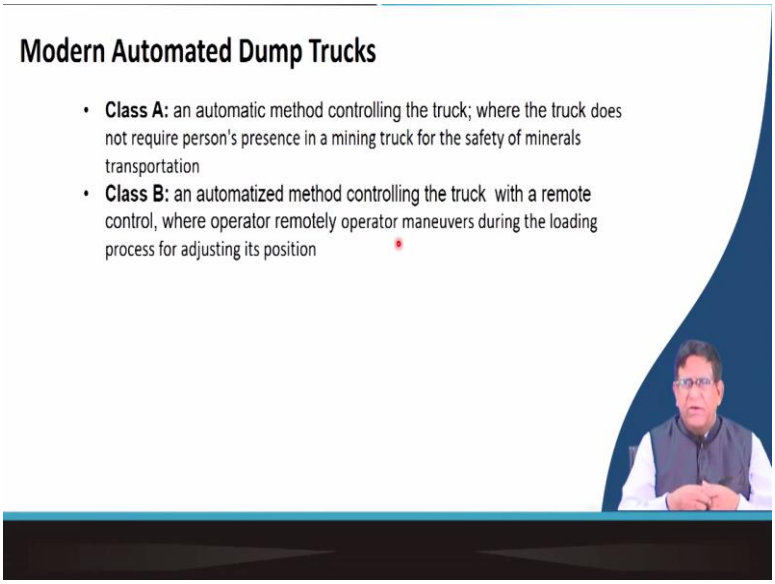

And lot of such a big modern automated dump trucks have come now this of two types they are available. One is that automatic method controlling the truck where the truck has not require person's presence in mining truck and for the safety everything is done automatically the other one is your with a remote controlling that you are having a operator with a joystick on his hand somewhere at a distance he and she can control the truck.

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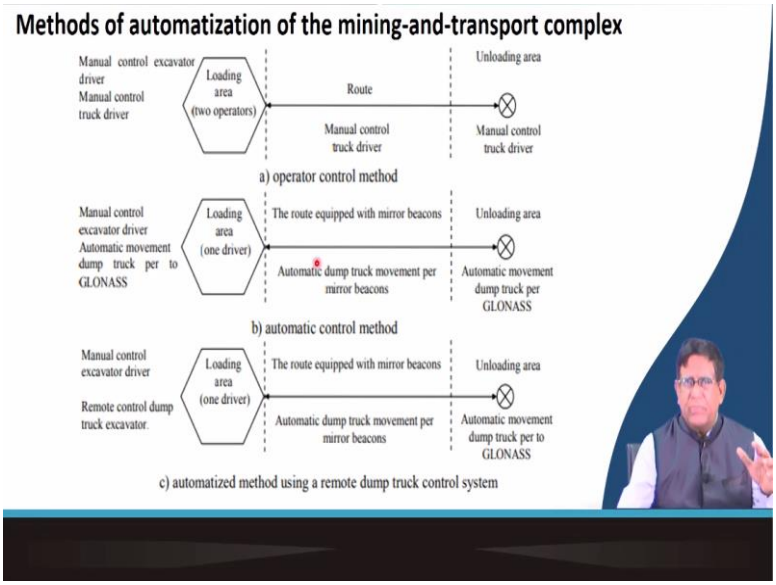

So, there are lot of things that how this can be done, the methods of automatization of the mining and transport complex where it could be that whole route and from the loading place to your unloading dumping place there either by your automatic dump truck that will be all without man less and then with a movement by a minor control can be given.

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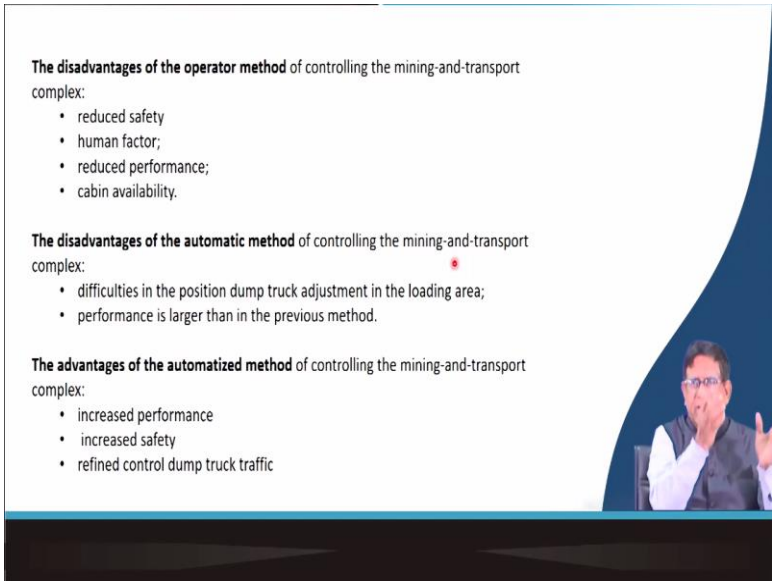

And this can be done either the different advantage will be coming in case when you are doing the operator method that means you are controlling the mining and transport complex method it will exactly the disadvantages that in case of when operator will be doing that safety is less human factor involve reduce performance and cabin availability, but when you are using automatic control there will be some difficulties in the position of the drum truck adjustment in the loading area.

So, sometimes if there is a little control differences where the shovel is loading over there if there is any error than the whole material will not loaded over there and the truck will start moving empty. So, that is why when you are using with a controlling and mining and transport complex then you can avoid such type of mismatches and you can control in a better way.

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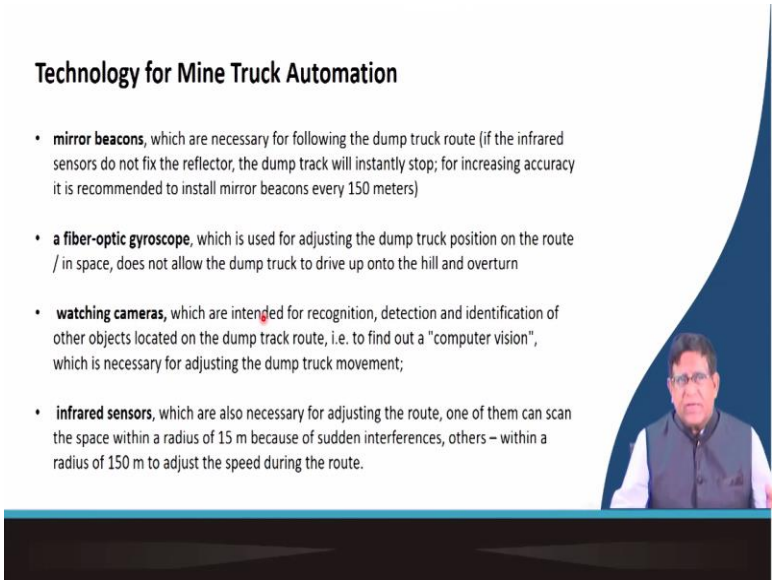

So, coming to this what type of technology you will have to search into this technology that there are mainly the mirror beacons that you say for giving the warning systems with that light itself it will find out see the reflector and then they give wording system. There are fiber optics gyroscope type of technology is there and then watching cameras are there, infrared sensors are there, these technologies need to be explored.

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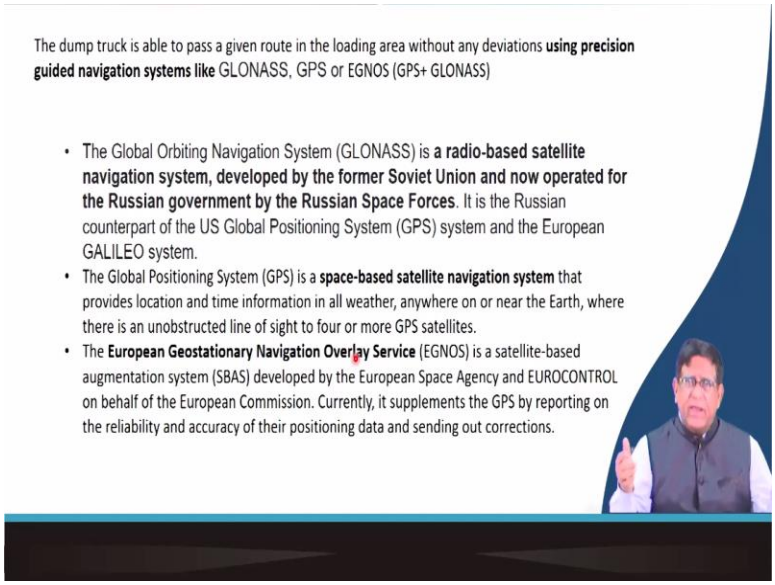

But the most important thing is there these are coming with a GPS system that their global positioning system has been used whether it is the global orbiting navigation system that Russia has given or they are using this American with a GPS system or your GALILEO system of Europe wherever satellite are there you are receiving sections in the truck they can be located their location is precisely done whenever their receiver will be locating at least four satellites their positions are precisely known.

The routes and everything is predetermined so that the truck can be controlled that navigation control system has come which are there earlier in a truck dispatch systems which used to be there from the early 80s, but only what has come today is much smarter. So, that earlier with the truck dispatch system with the locally within the mine with the radiofrequency there were monitoring these things and they were improving the allocations of the dumper with a particular shovel and taking the material.

So that you could optimize the time, but now that whole thing is coming as a automatic then there system control become more easier with the use of this navigation system.

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So, there are lot of developments in this area I have just given you a only introduction of it some of the references are there.

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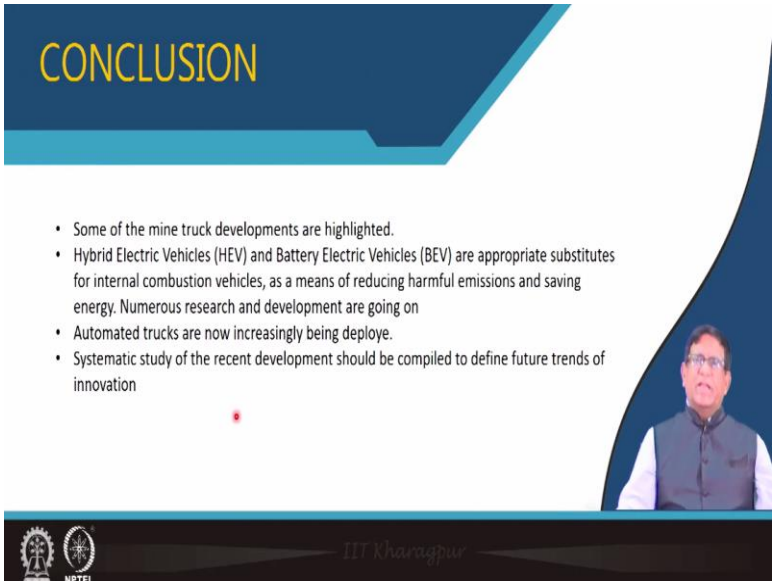

But what you must do is this is end of it. There are now many hybrid electric vehicles have come, better electric vehicles have come and there are number of different substitute for this our diesel engine have also come so that it will not be giving your emissions control will have to be there because this green house gases which will be coming from the diesel engine harmful.

So, there certain controls have come and then the automated truck has become now it has increasingly becoming popular in India it has not yet come in that way so we need to do some more work on it so that we can indigenously develop and retrofit some of our existing trucks for this things what is required is as a systematic study of the recent developments and then where it is there what are the available technology.

And then the students must do some of the best of study modeling and that best of study modeling proposes so whatever we have discussed here all the things you need not know, what you need to know is while the developments is taking place, take some small work as a simple project, take a learning activity and try to know that where in our existing system what are the gap and in that what new and simplistic method can be introduced.

So, this requires a little bit more studies, but I hope this is a introduction you will keep in mind and take some learning activity to make and prepare some notes on recent development, trend of developments of trucks and I hope in the next class we will be introducing some other type of transportation systems that are being used in our mines for large scale transportation of bulk materials. Thank you.