Mining Machinery

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Module - 10
Lecture - 54
Locomotive

Welcome to today's class on Locomotive. So, we are discussing about the underground mine transport system. And in this locomotive is another mode of transportation used in the mines and it is a very old mine transport practice and still continuing in many parts of the country. However, in India, we have got a very limited use of very few mines.

They have locomotive. Though we have got a history that in we had locomotive in Hindustan copper mines also, in the closed mines of Musabani. There were a couple of other mines where locomotives diesel locomotives that is and then, compressed air locomotives were used. And then, other than that locomotives are used in a surface mining transport also.

If you remember that in our old iron ore mines, that was in Dalli Rajhara mines that had a Russian design. A total railway locomotive transportation system connected with the shovels, shovel used to load on locomotives and they used to bring the material to their processing plant, but those are of course, have become obsolete in India.

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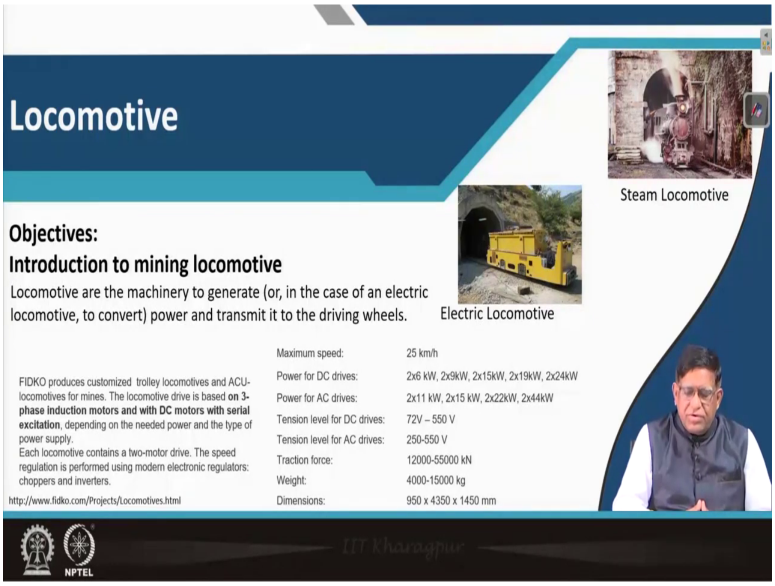

But the locomotive has got certain advantages as well as it is very much used and it is a good technology which are introduced. You can see here that say our objective of today's class will be just introducing you this subject that is where it is for example, you know the locomotive means this railway transport system where your trolleys or cars will be there on a track and that will be pulled by the engine.

Then, when we talk about the locomotive; it is that main engine part which exactly generate that motive force or the tractive effort is there which can be connected to a number of cars on the back to form a train and it is pulled.

So, this system had got number of different type of based on that what type of prime mover is used for generating as you can see this figure. In this figure, you are seeing this the steam locomotive here. So, there are many other form of locomotives as well.

You can see this electric locomotive where this electric locomotives are used very much in two forms of course, that electric motor will be driving the wheels of this locomotive and a that electric power it can be it can be obtained from that it is called a trolley line. That means, there will be an overhead electric line from which it can be collected and then it could be given over here.

Mainly, these were we say DC motor drive were given and this they used to travel at a higher speed like up to 25 kilometre per hour. This electric locomotive could pull a train. And then, they used to give depending on the type of design from 2 6 to 6 kilowatt motors or there could be 9 kilowatt motors 15 kilowatt motors depending on how much load it will have to carry.

And then of course, there is a AC drive AC locomotives have also introduced recently and in that we can they can work under a different voltage ratings it is available. Now, they can go up to 12000 to 55000 kilo Newton tractive force can be generated on this locomotive.

So, you can see that this weight car 4 ton to 15 ton of this your individual car the loaded car can be formed in a train and can be pulled. So, they are available in different dimensions the FIDKO, a company in UK; they were they are still producing this type of locomotive system.

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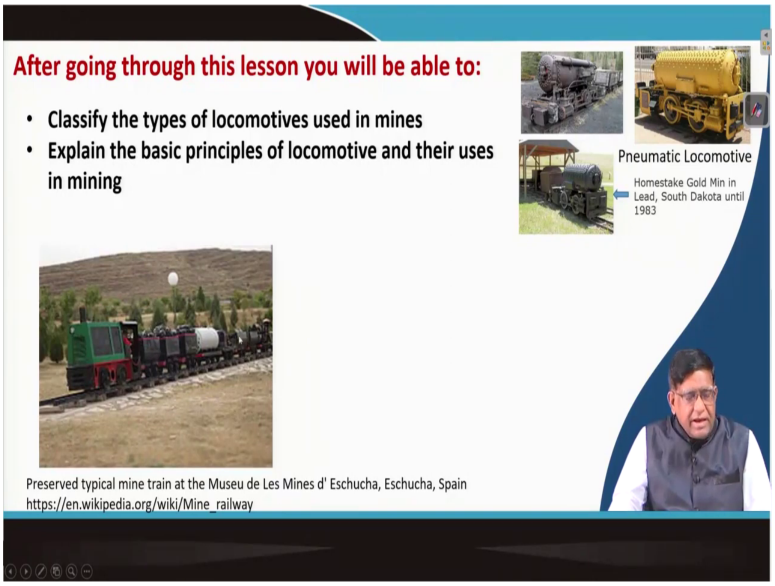

Now, in this particular lesson's, we will try to see the classification of the locomotive which are available or which have been practiced.

And then, we will be trying to know the basic principle on the basis of which you will be determining that how much power is required to drive a locomotive or how much load it can be carried. What will be an ideal gradient? What could be the maximum number of cars that can be pulled by a particular system; these are exactly discussed in this class I hope you will enjoy it.

That as you can see in this figure some of the old type of that is pneumatic locomotive. In a you have learnt in your that is a prime movers lectures that compressed air is being used in the mining industry for giving the power to number of equipment like that we talk about the drilling machines, this compressor driven drilling machines are there.

Like that you can see here these are the locomotive in which there will be a pressurized air tank is there and that pressure is controlled to just drive this piston and then you can make this locomotive to drive.

So, this is a system the other one that typically, they are driving this type of your total compressor will be there and then, the trolleys are connected at the back and then, they can carry the material. So, this type of locomotive systems were there.

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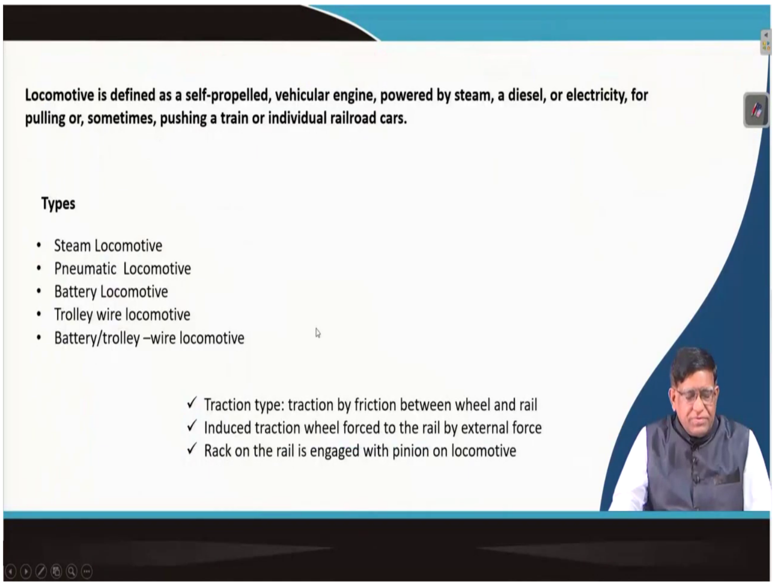

So, now coming to this. Now, you can note it down that locomotive is defined as a self-propelled, vehicular engine, powered by steam, diesel, electricity, for pulling, sometimes, or pushing a train or individual railroad cars. So, that is a generalized way you can tell that what is locomotive. So, that is a you might have seen in the railway stations whatever you have seen locomotive is that engine part over here that is the locomotive.

So, and in a that system your transportation system comprises of you are having the track then, you are having the engine then, we are having the bogies or the cars and then, combining together you will have to have this.

Now, the total the design of an underground coal mine or a underground metal mine where you are having this transportation; in that design you will have to take the whole system, how the total loaded cars will be brought. How in the sub bottom they will be giving, what will be the pit bottom layout when the cars are taking up with the loaded things then, how there will be a layout of the bit top layout those things are discussed in a designing a system.

Now, here we will be just talking about the machinery part of it then, what they are. In that, we can tell that there are different types like a steam locomotive. They based on the prime mover used. We can have a steam locomotive that is exactly earlier when the steam engines were there; these are rather the most that ancient and the first mechanization when took place the steam driven locomotives were there.

Now, those are obsolete. Now, though as I told you the steam driven locomotive were working in the Tipong Colliery of northeast coalfield, where it was introduced something around 19 1890 or so about more than 120 years ago. This type of steam operated locomotives were used where that same coal used to burn and the water they generate that steam and that locomotion’s were obtained.

So, pneumatic locomotive that as I as you have seen in the previous figure then, the battery locomotive; this is a we are telling about that now, electric locomotive. In the electric locomotive, it could be that you are having the storage battery on which you are having the power and then, that will be driving.

And this battery where exactly a bank of battery will be there and they will be in the mines. There will be recharging stations that after that shift, the all battery will be again charged back and then for the next trip they will be ready. So, like that a battery locomotives are used then trolley wire locomotive is where electric powers could be supplied through that and then, it will be connected.

So, these were the in to work with underground gas mines to make them. So that; there will not be any spark to ignite the this your fire damp that type of precautions and safety meters were there.

And then, there is the another type of locomotive in which a combination type in which that is exactly at some places where trolley wire is not there. It will be working on battery and wherever the overhead line will be there, they will be working on electric. So, that is there.

Then other thing is there that how this train with a locomotive can be made that system wise also. They can be divided as a traction type means; where this whole the power transmission is based on your friction between the wheel and the rail. So, that is a friction drive on that where you are getting the traction to, because of the friction then, it is called your traction type of drive.

Another is induced tractions in which the wheel is forced to have a grip over there and then it will be moving over there. And the other is a track type; that means, you are driving one pinion on the bottom of that your locomotive and that on the below on the track, there will be a in this your rack will be there. So, that it will be engaged and will be going over there.

So, these type of systems this innovative systems were there in the late 19^{th} century. And then, in the 20^{th} century there were a lot of things and if you go to Europe, many of the places you will find those in the tourist places, such type of locomotive are used for different purposes.

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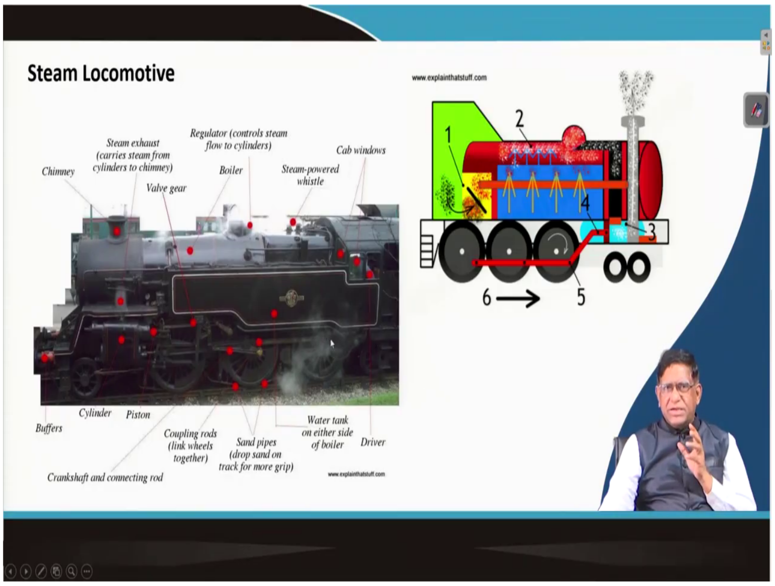

So, if you see about the steam locomotive basically, what is there? There will be the requirement wise, there will be water will be stored over there and then, there will be a fireplace when this will be firing at that time then, is your exactly steam will be generated over here, this steam will be this gate will get open and then, that steam will be passing through this.

They will be giving into this crank mechanism. This wheel will rotate and then, this exhaust that is after use that steam will be coming out it will be released over here and that going. So, this type of system it is there.

So, here you can see this is now, steam is allowed to pass through this and then, when it is posing this crank mechanism. Now, it will push this. This piston will be now pushing back and that stream will be going.

So, in this way that exactly whole that, if you see a locomotive steam engines, which were also used in our Indian railway quite some time, it was there early up to 80's; such type of engines were there in Indian railway, where the operator used to sit over here and the there were that assistant to the driver who used to keep on doing this fire.

Both side of this your boiler or that fire there are the water tanks this strain is to be filled with water and in every station and then, they used to burn. And the same principle is there which was in a real life, the make the design of the things were made over here.

So, you can study sometimes. This is too very good at least, if you have now what is called your crank mechanisms and how these pistons are allowed to move. How your this translatory motion is given to rotary motion and that rotary motion is given to again a translatory motion. These things are the basic engineering applications where there and then used to have it.

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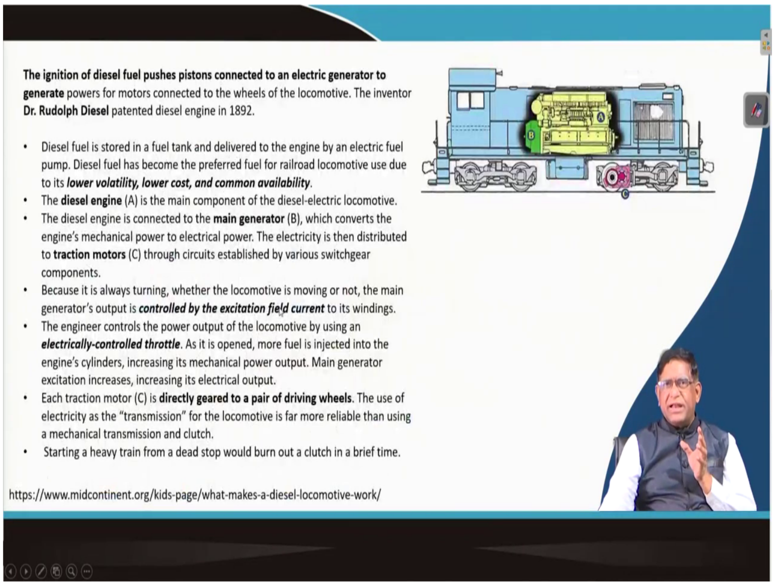

So, if you see that this in some machines not steam then, it going for the diesel. In a diesel engine basically, what they do they can work as a diesel to generate your electricity. So, there will be a diesel engine and that diesel engine will be running a here a generator. Now, this generator will produce that electric and then, electric current will be brought here in a motor which will be connected with the wheel and this will be rotating.

Now, this type of system which is there with a mainly with the diesel engine then, the main generator and then, the electric motor then, the whole engine they will have to have a different control system, how you will be controlling the motor, what type of braking system will be providing then.

Because it is a steel to this your that how that wheels will be made to move on the steel and that whole control will be there in this engine part. So, this is the locomotive then, at the back of it, there will be the your the connections that is the coupling point where you will be connecting the train.

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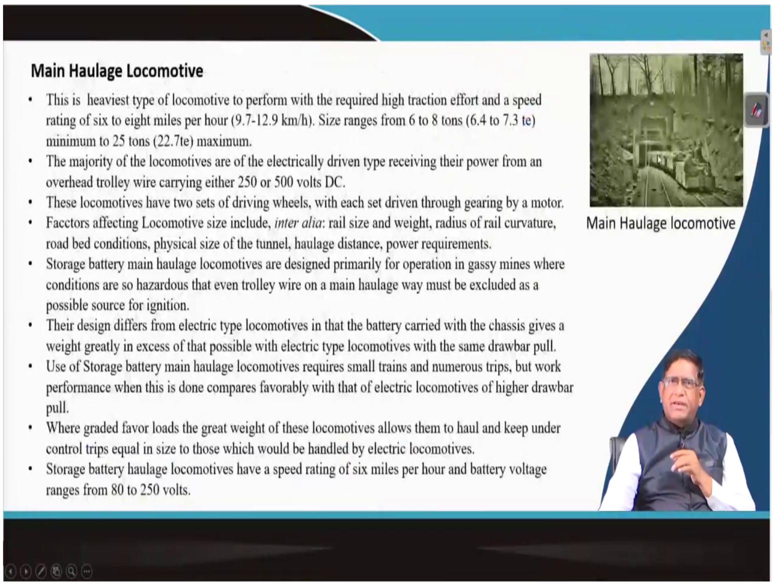

So, now, when you talk about the mining. The in the mining this locomotive haulage can be a different category. One is their main haulage locomotive; that means, which will be bringing out say, this could be in an inclined shaft; you have studied your underground coal mining method which could be done by a vertical shaft your mine access can be directly over there or that could be an incline.

So, if it is an incline, there you can have a trolley type of that electric wires are here and then, this locomotive through this particular connections; here, you can see that it is connecting this power is driven over here and then, it is rotating and then, the back side that all your train is coming. So, this main haulage drive, it is it will be carrying out all that; that is a maximum load will be coming over here.

So, the what is the basic component of the main haulage system; that means, you will have to get those stub loaded at the bottom. They will have to combine together connect together to form and then, couple and then, we will have to connect to the power systems and will go. So, this is the main haulage locomotive is normally, the it is the robust system.

Now, sometimes what happens this may have here, in this locomotive, you will be having a battery system also; that means, if at some places where the wire is not there, they can get the power from the battery.

So, it is basically, an electric locomotive that is a wheel's are having the electric motor, the power is coming from the overhead line or from the desert.

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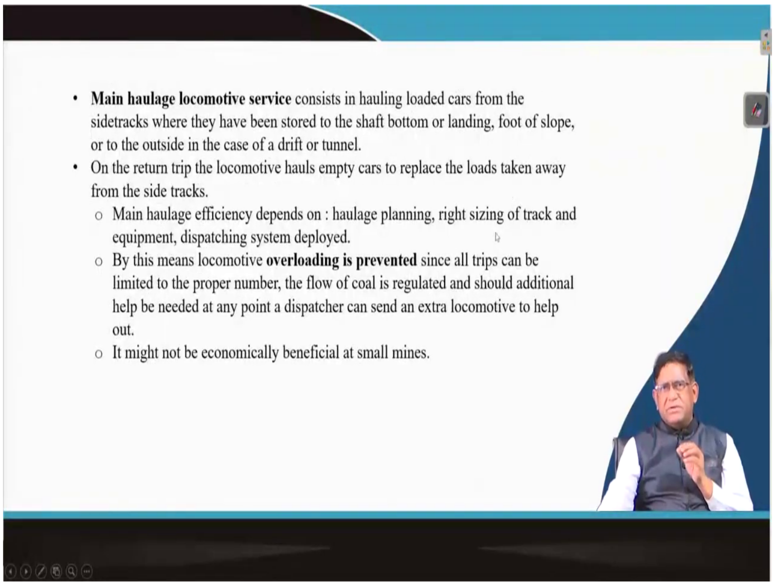

Similarly, this is a it is a it service consists of in the hauling load cars from the side racks where the they have been stored to the shaft bottom and landing. So; that means, basically, at the where your shaft and if you are going to a pit bottom there up to there, it will be working or in case of incline shaft, you will be bringing up to here.

So, now let us say while they are getting taking out the loaded stuff, they will decouple it. The engine will go back and then, there will be already queuing your empty trucks empty racks will be there. They will be coupled and then, they will be taken back over there. So, that is how as a main haulage locomotive will be working.

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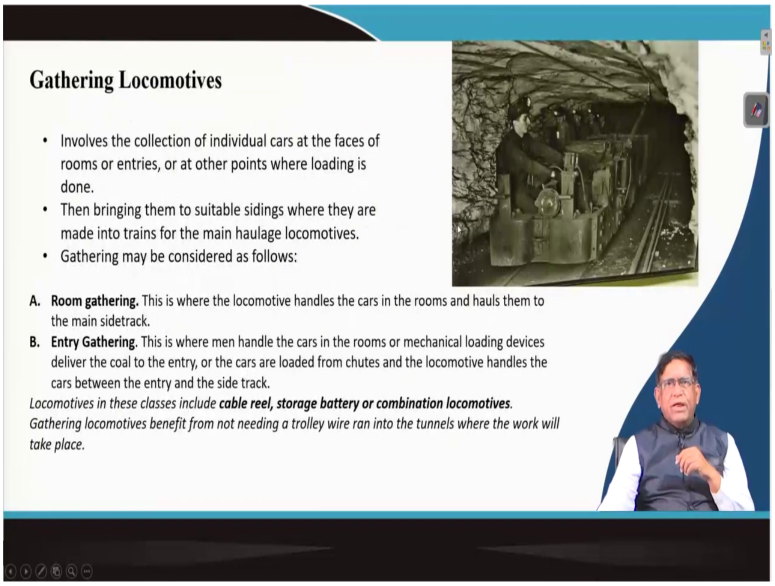

So, now, next thing is their gathering locomotive gathering locomotive. The name as it says that they will be exactly gathering different from the different sections of your that is there is a one main haulage road.

So, through that that main haulage road, it could be by an incline up to the top or it could be the main haulage inside the mine in a board and pillar method from different galleries, it will be bringing to the near to the shaft bottom or the pit bottom, where there will be the railway siding type of where you will be doing the shunting over there all the tabs will be brought.

Now, in a gathering one is basically, they will be going to that wherever the work is going on in the district, from there it will be collected and brought to the main thing. So, they can they can gather from different wherever the pillaring work is going on, from there it can collect and then also, it from that while your the development work is going on, from there also, it can collect and break to the main thing.

So, this is the way how the total transport route or the transport mechanism is planned in underground, there they will work. So, it is a purpose wise they can be get.

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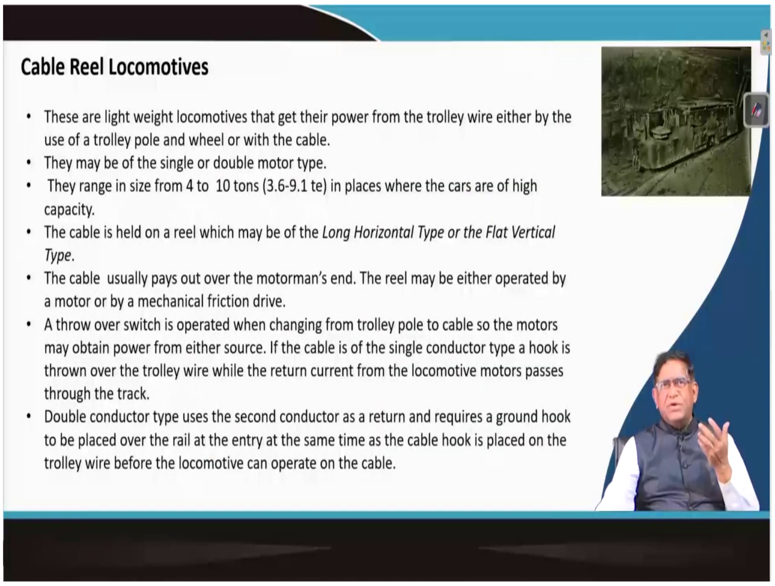

Then, another thing is this is a in a cable real locomotive; means, there you are having a cable which will be connected to a trolley systems up to one point and then, it can go to the end where there is no overhead trolley. But they will be as it will be having a cable reel, that cable reel depending on the length of it has got it can go for collecting or gathering the mine car to bring it to some places.

So, that is exactly cable reel is it can be a real horizontally it can be there over there or in the side it could be a vertically a reel will be there. On that reel from the main gate and box you can get the power or from the one the trolley wherever the access is there from there the power will be taken and depending on the length of the trolley it can go to the for gathering the different of mine cars.

So, that they can be brought to the your main end that say your haulage road from where the train can be formed and then, it can be carried by the locomotive. So, this is the system how the mining this transport in an underground mine is planned.

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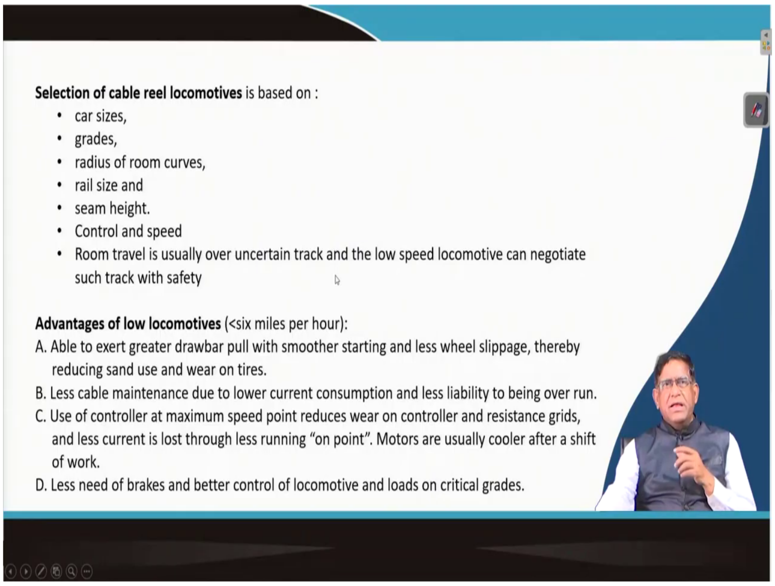

So, now, coming to this whenever it is either whether it is a cable reel or a your this that locomotive; what will be its size and what will be power. It depend on exactly that what are the car sizes depending on if you may have a 3 ton mine car or you may have a 2 ton mine car or you may have even 4 ton mine car; depending on that how much load it can take.

And also, it is called a tear weight that is the there is a self-weight of that car that will have to be taken, because ultimately there is one thing. You know that the drawbar pull of a locomotive means; that locomotive. Because of its engine fuel or that whatever you are having with that what motions you are going to get, that is called your tractive effort.

Then, what will be the resistances that whole train will be giving, because of their self-weight or there could be, because of their inclinations there will be a resistance that when you subtract all the resistances from your the tractive effort, which you get that is called your drawbar pull. Now, that drawbar pull how much will be available will be depending on what will be the car sizes or that what type of weight will be connecting over there.

Similarly, that your locomotive how much what will be that what type of motor power you will be selecting will be depending on at what gradient it will be working. Will be discussing soon that how this resistance is come then, on that rail on which your tarp cars will be there, their dimensions also affect your system.

Then your what is that exactly the gallery height, because you cannot operate with that then, whether your two tracks will be there that gallery dimensions also will be working. And of course, the whole selections will be depending on what speed and how you control over there.

So, overall, that is your whole locomotive system you should always maintain that you depending on the systems the and that considering the safety, you will be making the operation parameters.

So, you can find out that this is exactly the there are all the different type of locomotives; they have got their own advantages and disadvantages. So, because the main thing is there that how much that your efficiency will be depending on that your system productivity will be depending on how you are exactly utilizing the available power for trying; that means, how much dropper pool you are going to get from that equipment.

And for that, exactly this another things you will have to see that how much that system will require maintenance and how much fuel it will be consuming and then, from those point of view this your cable drill locomotives are found to be cheaper compared to the other mode of transport.

Because of its operational is flexibility, other things can be given here and then, this therefore, the controlling also there is a there is less requirement for the this brakes and those point are affecting in main designing of the system.

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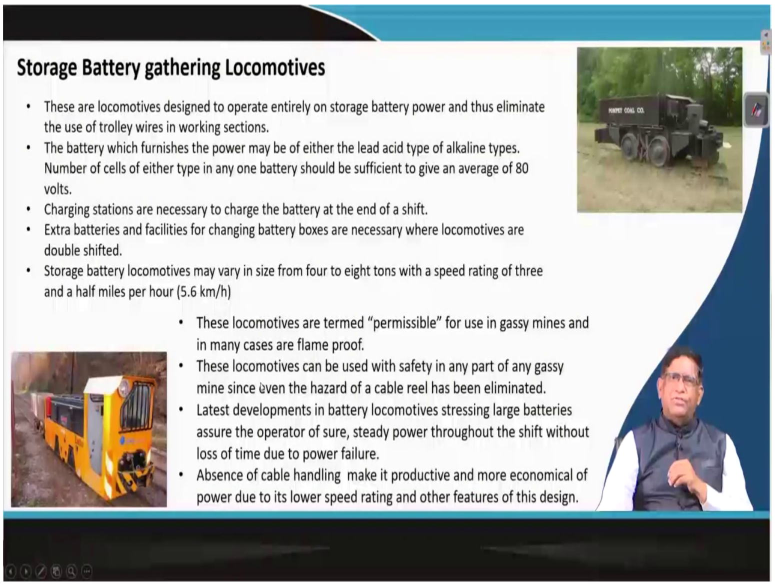

Nowadays, as we said that electric locomotive can be having also a storage battery gathering locomotive. That means, this gathering locomotive going to different districts and collecting the material, they can have a their own battery. With that battery, they will be waiting. So, they did not depend on that up to the working phase. If the trolley or the power supply is not given, then also this system can work.

So, they are designed to operate entirely on storage battery power and thus eliminate the use of trolley wires in the working section. So, this is the main advantage of this system ok. So, this is also the type of that lead acid type of alkaline type of batteries that those are used and then, this battery can be charged. So, that is why in the mines there will be a charging stations so, by which exactly you can economically plan to get that power available for this.

So, they can go of course, their speed and all it is limited to 5.6 kilometre per hour and a those type of restrictions are there ok. So, they whether they will be working in some of the your underground mines, where the trolley if it is going.

When you are taking corrections at that time a moving if there is a chance of sparking, so, that is why in some places they may not be permitted. But this type of battery locomotive gathering battery locomotive, they can be made easily for that your the battery will not be leading to any spark and then, that point of view it will be made as a permissible. So, those arrangements can be there ok.

So, this is a as you can see here, there is no cable so therefore, no cable handling. You will find in many of the underground accidents. One of the major source of accidents is the cable handling, whether it is in your locomotive cables or it is for your shuttle cars which you are using with a cable moving under the mines is a. So, that is why this battery locomotive when they are using, they will be giving you better performance.

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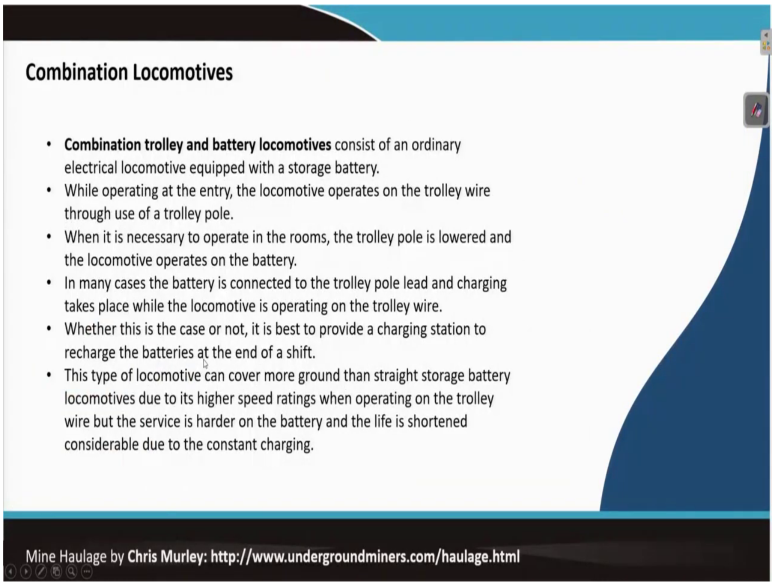

Now, sometimes these two can be combined together. The combination of trolley type and the battery type then, wherever required you can switch over. So, this type of systems has got the advantage of both battery type and the cable type can be done over here.

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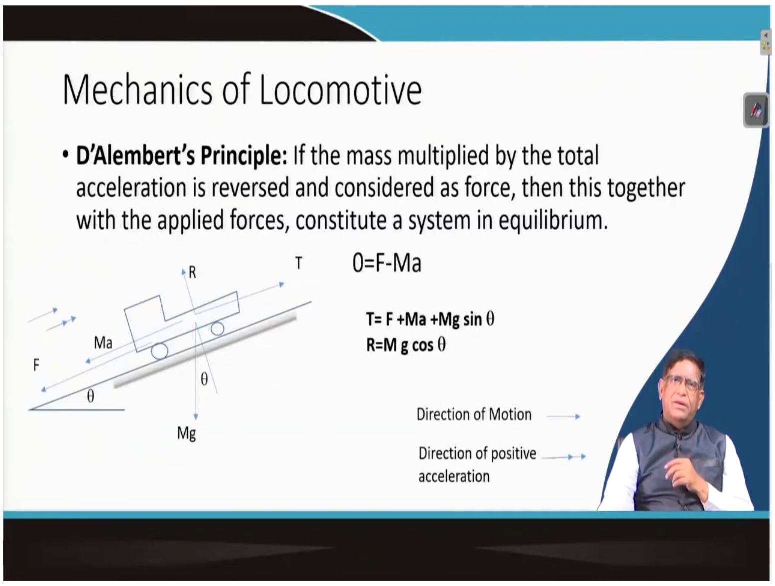

So, I think by now, you have learnt about that what is a system of a in case of your a locomotive, you are having the trolleys and then, you are having a driving engines and they will have to be introduced.

So, now the basic thing is what type of what should be the engine power how much power will have to be given that how much that is your drawbar pull will be available, what will be the tractive effort; this is based on the D'Alembert's Principle, which you know this is just a another way of telling the Newton second law.

In the Newton second law, you know that is F is equal to M a, that this part only what they say; that means, whenever there is a dynamic system like this, that is exactly the your total force systems that will be must multiplied by the acceleration. These ones when you take there that equilibrium, this equation is given as a D'Alembert's Principle.

And here, you can find out that what is this total force that will be required; exactly that whatever the gradient force is coming and what is that your inertia force is coming. And that depending on what is the normal reactions. So, you can see here all the motions and the forces are given over here from there you can find it.

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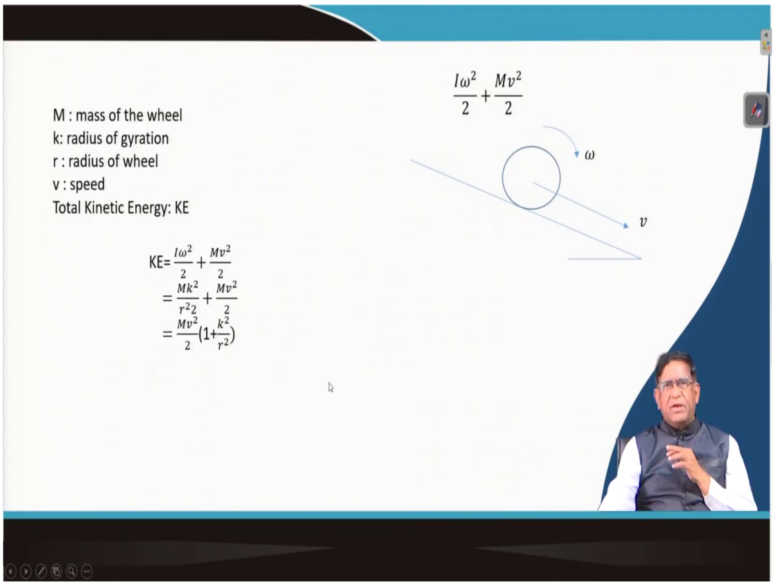

So, even in a then when a will be rolling down; that means, it will be having an angular velocity and then, it has got a that is your what is that the your total the your moment of inertia. And then, your radius of gyration they will be affecting and you can easily apply your school physics that the total kinetic energy; how much it is coming. It will be I omega square by 2 plus M v square by 2.

So, these ones exactly you can see that total mass that is a M it is your, because of the radius of gyration's; this is the total kinetic energy coming over here.

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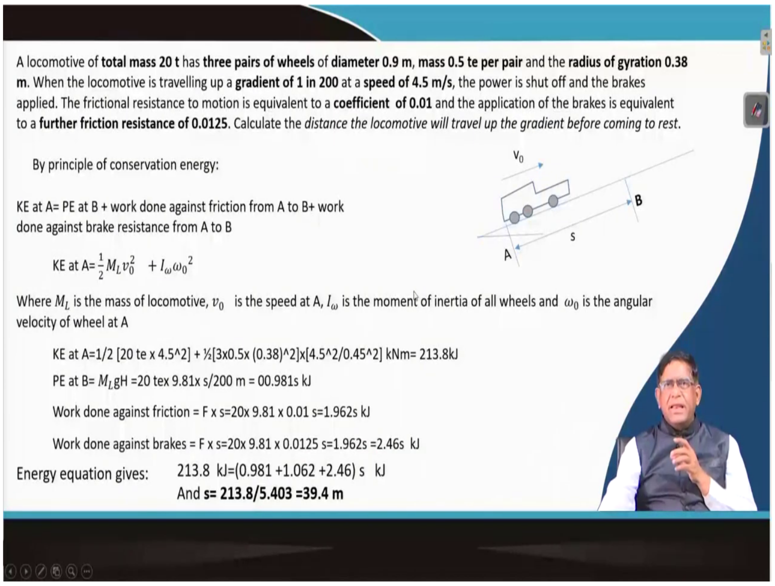

Now, you can applying these things, you can do some small numerical to understand what it is there. A locomotive of mass 20 ton has three pairs of wheels; you can see over here and then their diameter is given and then, the mass per ton per pair is given. Now, the radius of gyration is given and when the locomotive is travelling up a gradient in 1 in 200, then at a given speed the power is shut off and the brakes applied.

Now, the friction resistance to motion is equivalent to a coefficient of this it is given, because that overcoming the resistance and then, you can apply the brakes how much will what will be the further friction, coefficient is given.

Now, you can calculate what will be the if you apply the break, after what distance it will stop that stopping distances. So, it is just only by applying that principle of your kinetic energy, you can easily find out this equation.

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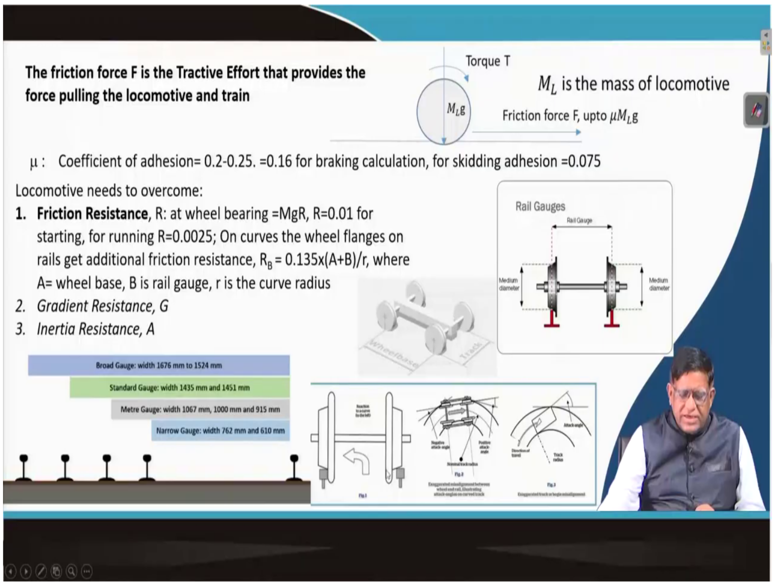

So, similar type of problem you need to solve. So, that is a friction force is a the Tractive Effort that provides the force pulling the locomotive train. Because whenever it is there you are from the motor in the locomotive, it is giving a torque.

And it’s weight is there when you are moving it there is a frictional resistance to motion. That means, your that as you know that from the principle of friction for rotating in these ones that weight into coefficient of friction that will be giving you the total frictional force.

So, to drive this ones at least equal to this. So, that is why your the total friction force will be coming as a tractive effort. So, these ones you can do now, when you are having a track, you should remember that there are two things that there are or the track will be two rails; the distance between the centre point of this two that is called your tech gauge.

And there is a from the distance between this the to the centre of this wheel, it is called your wheel base. Now, in a railway or any track what you will find your this railway wheels, you are having a little bit of tapering.

Now, why it is required? You can easily understand that when there will be a curve so that; this different point will be getting connected and then, that your drive will be taking place.

So, that the dynamism the dynamics of a railway wagons moving on the this rails that is a very interesting things, but one thing you know that the different goals is you know that in our country we have got narrow gauge, we have got meter gauge, you have got standard gauge, and we have got broad gauge.

So, this is a that these are all standardized as you can see from here that is your 1524 millimeter; that is in different country they may have a different definitions for how much will be those narrow gauge or what will be the broad gauge, because these standards are maintained. There are other, because of some of the operational and maintenance purposes.

But what most important for you to know as an understanding you can see here this rail. When it is running over here, at that time when you are taking a train you see that the wheel is not exactly at the centre, this wheel is coming here up to the flange and it has gone a little bit away from the flange.

Now, when it is there are four wheels two wheels here, it can be seeing and then, there will be a transition point so; that means, when it is taking a turn, at that time these portions that which one is connecting that will be there. So, once you draw this type of figure that is your we know that what is that attack angle; that positive attack angle and this angle will be changing when you are taking a turn.

The whole dynamics of it when you study then, you can find out that what should be the wheel base and all depending on your what will be the railway curve and on that exactly what type of trolley or what type of car can move on that. So, those things are the detailed study when you want to do.

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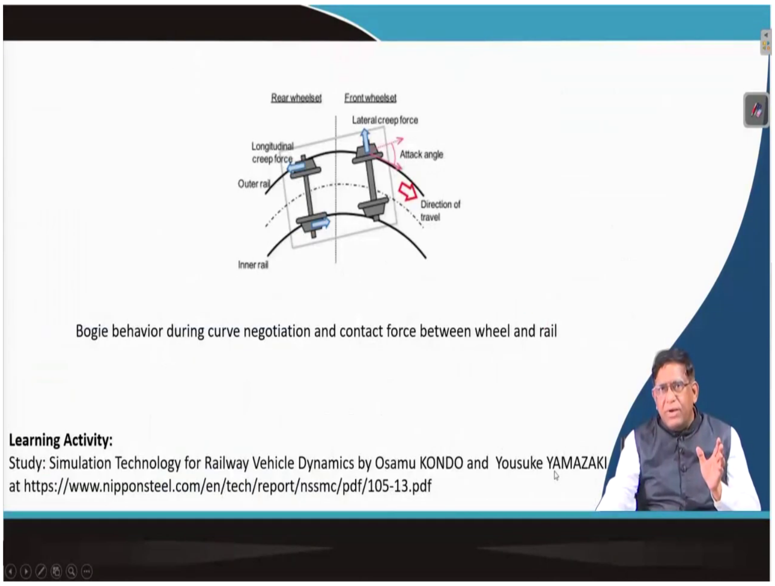

But this is very interesting on that as you can see over here that is there will be a creep force coming up there. This attack angle and then, this two type of a lateral creep force and this is your longitudinal creep force coming on to the outer rail.

And then, if it goes out if your railway gauge is not properly assigned not properly designed then, this will may go out and then, there could be the derailment and there could be the accident.

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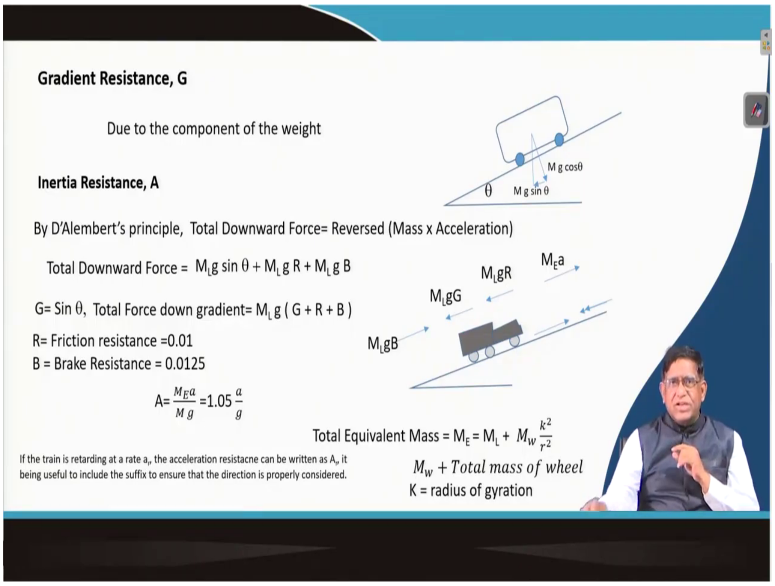

So, this point exactly how the buggy will be behaving on this. You can study some of the research article if you want to study more, but thing is that these resistances you can find out that when a trolley is to move over here, there will be different resistances coming over here.

First is your total M L is the total load which is coming on this truck and the loaded number of them which have been corrected. So, this will have to be with a particular acceleration's going up. So, that is the power requirement, but there will be resistances different resistances will be coming, because of the total load of it, because of the Grade resistance and because of the that G is that Gradient resistance then, your Inertia resistance so and that the Friction resistances.

So, these three resistances will be working on it, when you account for that then, you will be finding out the calculation is very easy. So, this Inertia resistance; Inertia resistance can be calculated by this; that means, if you are having that is a your total mass which is coming over there normally, that at what accelerations you are going it over there and acceleration due to gravity there as a ratio at about 1. 0 5 8; this becomes exactly a Inertia resistance, which you can use it over here.

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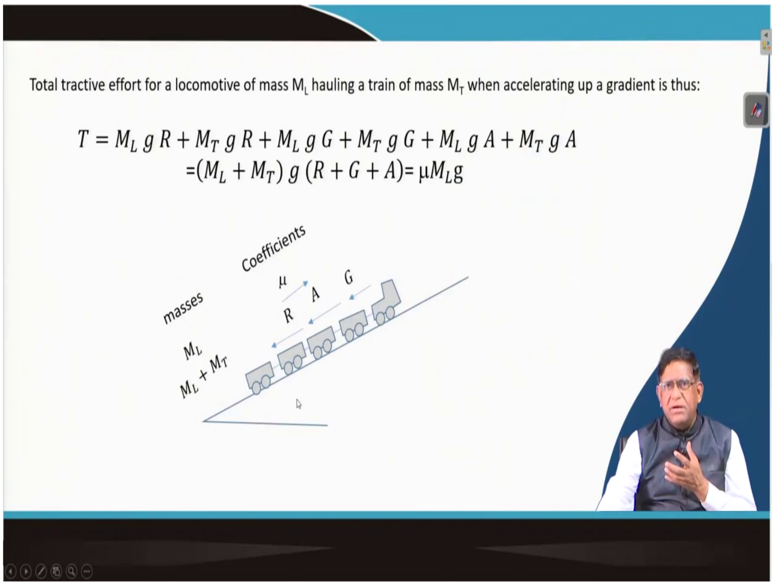

So, when you find out the tractive effort, the tractive effort will be depending on that exactly total what is the mass load of this that is that. This locomotive part what is each this is M L of this part and then what is the M T. M T is the total load on this all cars together and then, multiplied by G; what are these resistances that is your the Friction resistances, Great resistances and your Inertia resistances.

If three resistances are connected that should be equal to at the co-efficient of friction on which it is moving the whole mass is giving this thing. So, this is the way how you calculate out the locomotive this the total forces.

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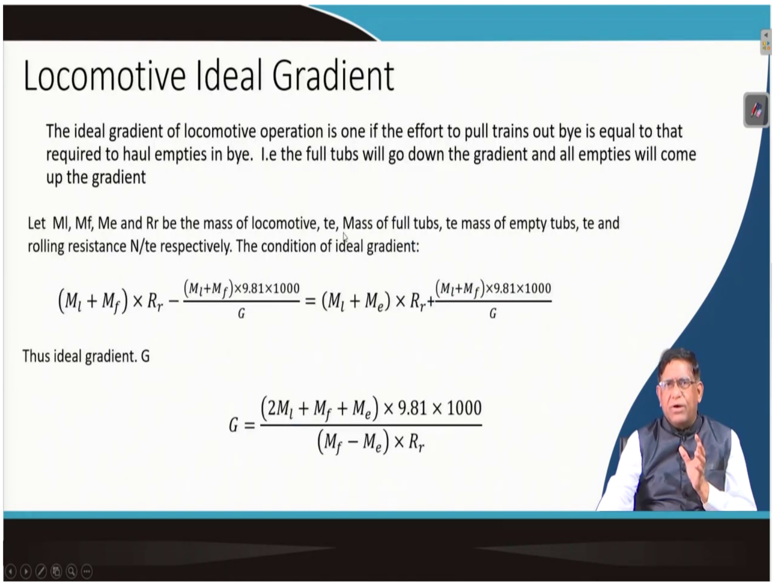

So, from there equations comes that what is an ideal gradient. Ideal gradient means; suppose, you are having that is your that it is a gradient of the locomotive operation that is the effort to pull trains out bye is equal to that required to haul empties in bye so; that means, your empty cars when you are going to take downward and that one whatever the force will be coming resistances will be coming and then, when you are taking the this the loaded one upward that should be equal.

So, you can see here this is your that M l is the mass of the locomotive then, your M f is that mass of the full tubs and then, M e is the mass of the empty tubs and then, R is the rolling resistances.

Then, this is the your that while the full loaded tub are going that resistance is multiplied this is the things minus f as, because you are it is opposed by this your gradient you know if it is a 1 in 10 or 1 in 15 that G is that gradient this much and then, it is equal to when your this empties are going then it is plus, because it is in favor of the gradient.

When you put this together; that means, the loaded one moving against the gradient; empties are going in favor of the gradient. Under these conditions, this gradient if you find from this equations, this is called your ideal gradient. I hope it is clear the ideal gradient.

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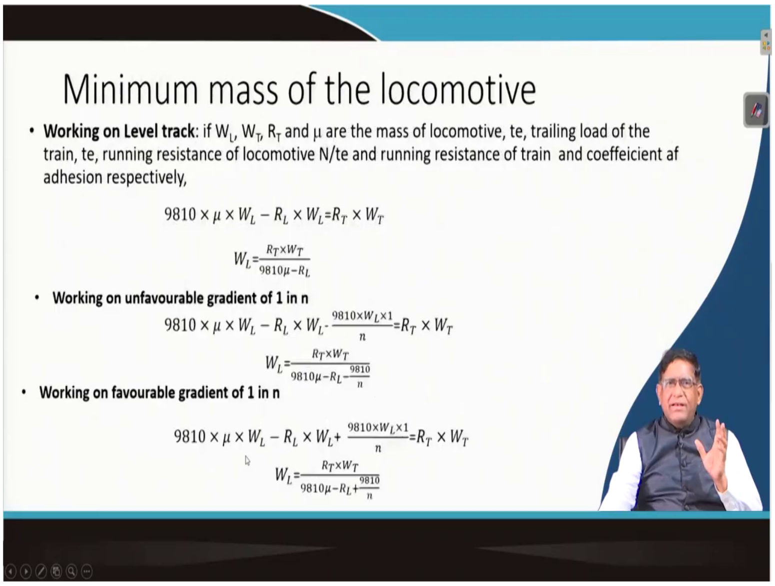

Now, that what will be the minimum mass of that locomotive that is exactly that your whole force and all what will be coming. The tractive force that is a function of the mass of the locomotive. So, what should be the minimum mass that the locomotive should be there.

This will be when it is working on a level track, when it is working in a gradient and then, while it is going in a unfavourable gradient and when it is going in a favourable gradient, this total weight of this exact this mass of the locomotive that could be different that you can calculate it out and you can find out.

That means, whenever you are selecting a locomotive, that depending on the weight of the locomotive which is there you can tell that how many cars can be connected to it. So, that that is that the weight of the locomotive is a very very important, because the tractive effort which can it can generate is depending on itself weight.

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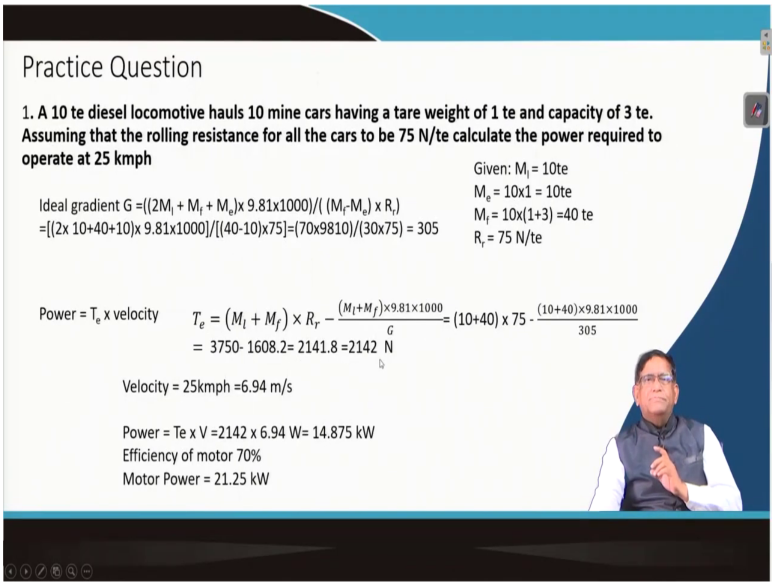

So, now, you can take a question’s you can practice this. Suppose, a 10 ton diesel locomotive hauls 10 mine cars having the tare weight of 1 ton and capacity of 3 ton. Assuming that the rolling resistance for all the cars be 75 Newton per ton calculate the power required to operate at 25 kilo kilometre per hour.

If you see; that from the if we consider the ideal gradient conditions; from there we can find out what is gradient, we are finding out G your gradient is 305 so; that means, this system can be working as the ideal operation condition is up to 1 in that is 305 this slope it will work.

And then, you can once you know this gradient your given parameter you take it then, you need to find out for power, you will have to know what is the tractive effort. The tractive effort you already know that is your depending on your loaded car and then, this what is your it is against the gradient.

So, from here, you can find out the tractive effort you know the velocity given in your kilometer per hour. Convert it to meter per second. So, velocity is known, tractive effort is known, you can find out the power.

If you know the power then your if you know that this the motor power that is efficiency of the system is 75 percent. So, divided by 0.7, you will get this. What will be the motor power required. So, these are very simple calculations you can do it over there.

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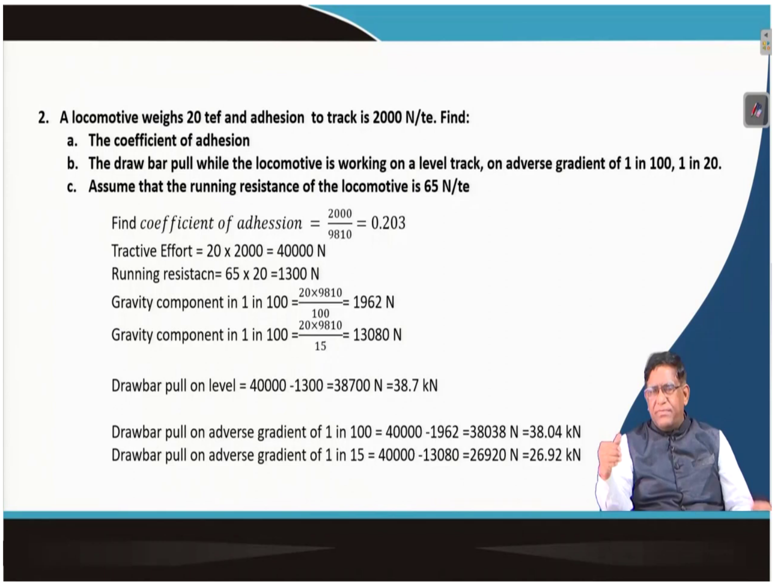

So; a locomotive weighs about 20 ton force and the adhesion to track is about 2000 Newton per hour. Find the coefficient of adhesion. Now, this exactly you do not know that coefficient adhesion is very very important.

Because on that basis only your whether you will be able to run or not and that is why to improve that adhesions and all you may be knowing that is exactly for improving the braking power and all the put sandbags; that is all the locomotive they have got the sanding systems and all that. So, this is also the same formula which you are there you can use it and then, you can get it.

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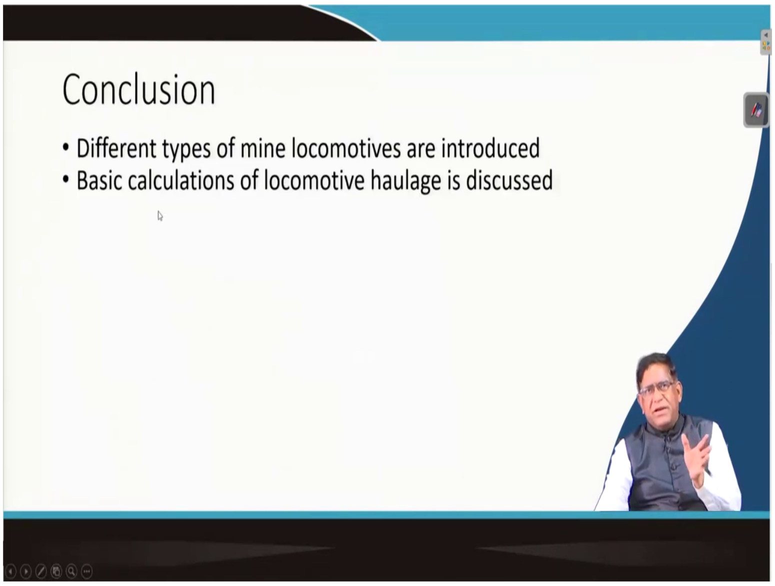

So, what I have said here today is a basic what a locomotive system is and we have discussed about the basic calculation things. I wish that you read about this particularly that mine transport by N.T. Karelin this book gives. And also, the Mechanics of Bulk Material

Handling by Norman Brook that is exactly a 1971 book which is very good for basic understanding of the locomotive.

Then, other than that; you will have to do a little bit of internet search for different research material and you can do it over there. So, I hope that you will be doing this study on locomotive and see how it can be used.

On the basis of it, you can find out a lot of maintenance of that system how to deploy it over there and then, how to manage that technology in a mines. This will be giving you a good creep on the operating and then, you can compare with the other form of transport system and that cost calculations, cost comparison can be done for getting a basic your management decisions.

So, I hope you have now understood that what is a mine locomotive and how you should prepare yourself to know about it. So, there are some D C M S circulars and legislations. So, you please study the mines act and legislations which are essential for operating these systems in any mines.

Thank you very much.