Mining Machinery
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Module - 10
Lecture - 51
Machinery for Underground Mine Transport

So, welcome students. We have been discussing our Mining Machinery. We are now almost nearing to the end of our discussions, though there are a quite a large different type of machineries are there. But we cannot in a one particular course; it is just only to give you an introduction.

So, today, we will be discussing about the Machinery for Underground Mine Transport. So, it will be just an introductory class and then, we may discuss few machines in our subsequent classes.

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So, today, our main objective is to give you a overall view of what this underground mine transportation system is there. Some of the things you can see over here in this figure. Try to see that a these figure which shows there at depth, you can see the mine tubs here, which are being connected to a rope and this rope is pulling them down, that is exactly which is quite often it is said as an underground rope haulage.

So, in a mine transports, this method which is now almost 100 years old. This is still continuing in many of the mines with some advanced person of it with a we have this endless rope haulage. We will be discussing some of that in separately. Similarly, in this you can see also a diesel look diesel engine operated, this type of arrangements for men riding system in a mine is there, where we can have even a locomotive; underground mine locomotives are there.

You can see here a conveyor belt in an underground mine; a conveyor belt is running over here. Other than that, there are men riding system for transportation of men, you can see over here how a rope haulage has been used.

Just like in your aerial ropeway, you are having it at a underground that is a suspended carrier on which the man travels, say a schematic diagram is also shown over here. In one of the class, we may discuss a little bit about this. This system is also there in our Indian mines as well as many mines abroad.

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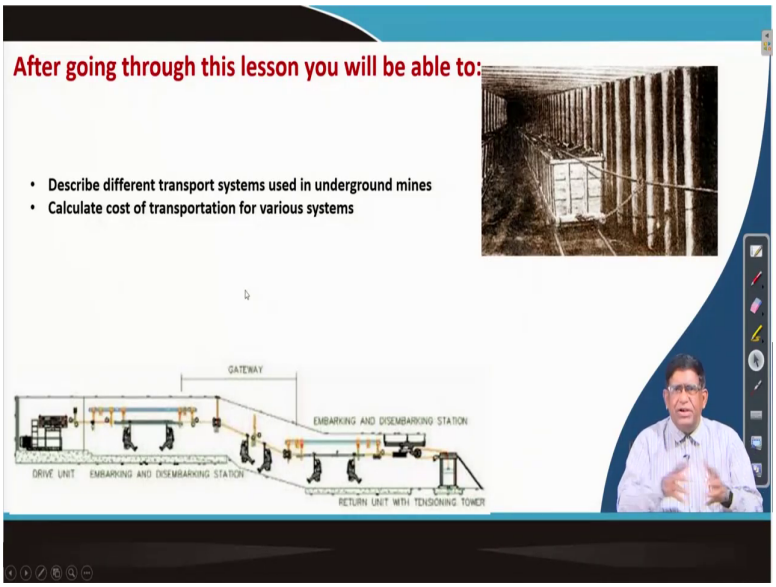

Then, this is exactly here; this is a man riding system of a mine is shown in this figure. A rope haulage is shown over here; how on the mine car, you can see here in a there is a tracks that is

why the track system that whatever the railway track same system is there in underground, which can be used for rope haulage or it can be for the diesel locomotives.

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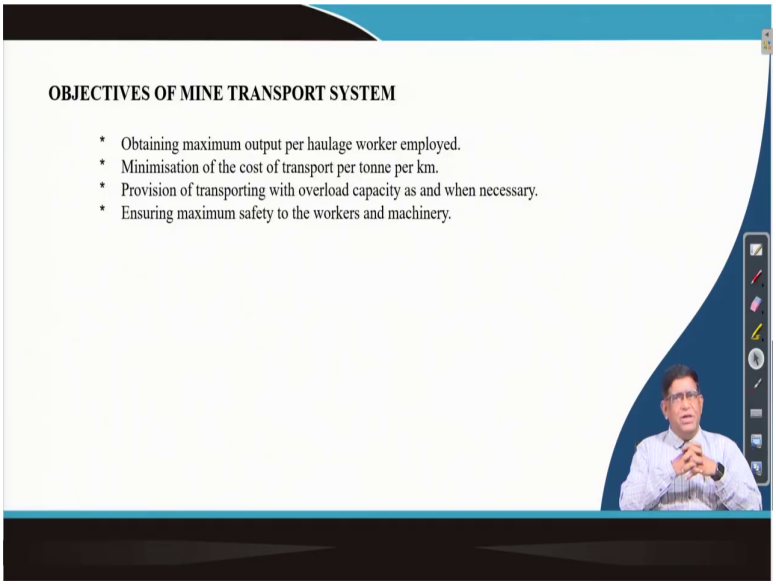

So, in this class, we will be describing as a general some of the basic understanding that is required to study this machinery. And here, what is the main objective of a mine transport system? Exactly objective is very clear, we need to bring man and material down to the mines for doing operations and then, whatever the excavation work is carried out there, the minerals which is our price there will have to be owned and evacuated from the underground to the surface.

So, that is where exactly the system will work. But that will have to planned in such a way that it gives maximum output per haulage worker employed. Depending on the how many

number of people who have employed, per persons, the material live it should be more, that is what is an objective.

Then, minimization of the cost of transport; obviously, that will lead to your profit. Then, there should not be in a transport system when you design, it anytime there could be more demand for the material. For that purpose, we will have to have some overload capacity.

Then, the most important thing is in underground mining, you are working against the nature and that is why there could be at any time accident may take place. So, you will have to keep the equipment in safe condition as well as the person must not suffer an injury. So, because of this, we keep the system to be designed. So, that it helps like that.

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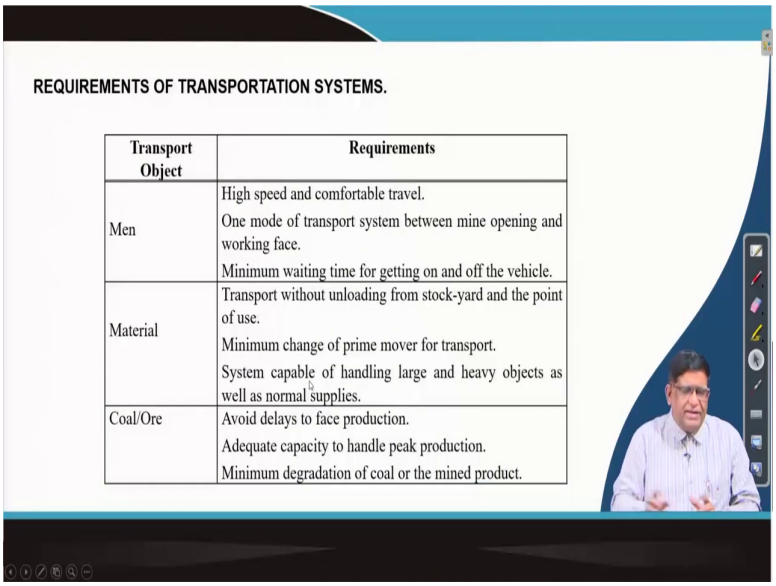

Now, as we can see the requirements will vary depending on the purpose. So, if the objective for carrying man, then have to you will have to see the requirement, it should be speed should be not that high, that it is becoming uncomfortable or it should not be that low that you take a lot of time in going to the face for walking.

So, that is your the mode of transport between that your where is the opening, from the mine opening to the working place where it is there, that will be the main requirement. And then, there if you are using some men riding system, your workers there will be 300-400 workers working in underground mine. They should not be kept on waiting that when will my turn will come and I will be lifted to the surface.

So, that is why the that convenience that for depending on the number of persons, who are deploying in the mines your transporting system or your man riding system will have to be designed in such a way that you can within that is it that shift change over. When you are a person will have to go into the mine and some person will have to come out of the mine, at that time the type of the rush hour, the traffic will be there on the riding systems should go smoothly.

So, what speed and what type of, how many number of such facilities will be located, that will depend on that. Then, the material transport what is there, there is a if you are taking out the mineral to take out from there, we will have to take up to the surface and then from the surface, where you are stocking to take up to there, you will have to think as a whole system.

Then, your that is your the type of main prime mover that whether you are using diesel engine or electric or you are using pneumatic power that your it should be a as far as possible a one type of prime mover if you use, then from your operation and maintenance point of view, it will be user.

So, then another thing is there in the mine sometimes you may have a high volume; volume is bigger or a weight is more, the different type of objects may be coming. Sometimes, you will may have to take a pipeline on down to the ground and that below the ground or you may take

a big pump from the surface to down. So, that means, there is a wide variation of the object to be transported.

So, for that, the system will have to be comfortable. And then, your the loading and unloading system for the bulk material coal or ore, iron ore or this zinc ore which is being mine from underground.

You will have to put in such a way that there is a proper loading and unloading system is there and the people do not have to wait for the that your carrier to come and then, to go. So, that delay in queuing of the carrier for getting loaded or unloaded should be minimum.

So, that is a basic general understanding. It does not require a lot of your engineering skill; but first your what you exactly want, you need to think. So, when as an engineer job, if you are respecting yourself as an engineer, the first thing is to know that what is my requirement.

Then, we think ok, if this is the thing, then what way we can engineer this and for that, you study that how people have been doing. That is why when you are doing an academic study, we will study that existing system.

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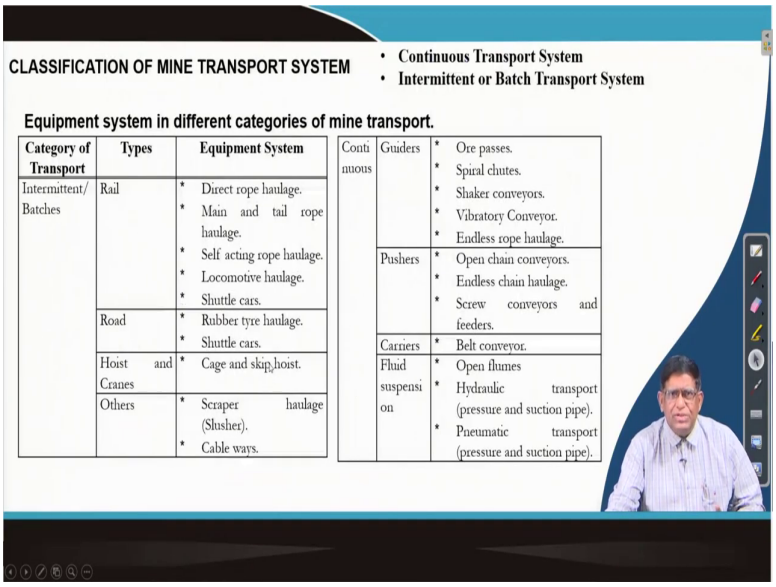

And then, we will be going for what type of new innovations can be made or what that existing systems, how its productivity can be used, how its availability and utilization could be made better that is what is exactly when you are going to study this. Now, there could be a that when you are thinking of an under from underground, you will have to take the material or you have to take the material from surface to the underground, there could be different category.

Two categories are very prominent. You can think of as an intermittent and continuous. That means, your transportation system will sit intermittent or batch, if the material is taken on a container and then, it is taken over there empty and then again, you take it and bring it over here.

So, it is exactly the material loading and unloading is not happening continuously. But in continuous system, what is there? Your transporter is going on moving continuously; there is no stoppage of it and your material you are pouring over there and it is getting taking over there and then, when you are loading; at the same time, other end something is unloading.

So, loading and unloading are simultaneously going on continuously. So, this is what a difference of intermittent and continuous. Now, for the intermittent type, now you can easily think that you all of you have got that experience of travelling by train. It is a one stations; you are coming from Delhi to Calcutta. You got up in Delhi; you will be get down at Calcutta. Again, that same train will be going back and then, coming this is a intermittent system, railway is a intermittency.

In that a batch of people will be going and that, that is number of wagons are connected. So, that is the way that in mines also, you will be bringing up the material loaded onto a wagon type of things which we will say as a mine car or mine tub. Taking that material over tub, now you just like in a train, your connect them couple them one to another and they will become a train and they will become a now batch; you take this.

Now, to take it up, we can use this rope; then you will say it is a direct rope haulage, from one level you can take it to another level. Then, you can have a locomotive. You can this rail and then, once this is say you are you are having a track system which can be with sometimes.

There could be shuttle car also can be put on rail, there is a your locomotive can be put on trail. There could be endless rope haulage; direct rope haulage; main and tail rope haulage; different type of rope haulage we will be talking about it.

Then, there could be trackless transport; that means, no rail underground, then it is called your trackless. There the transporting machines will be rubber tyre mounted machines can go, you have seen about the shuttle car which is working with your continuous miner in underground mine is a transporting like that you can have a low profile dump truck.

If you go to Uranium mine, say in Jaduguda; if you go down in underground mines in that your zinc mine in Rajasthan, you will find that there are trucks going down to the phase and then taking the material by the truck. But those trucks are of low height, they have got a long carrying capacity, few tons material will be brought over there and then, that is called your low-profile dump truck or a low profile truck.

Similarly, there is another system you have seen from the underground, you can transport you might have seen anywhere that the characteristics sickness or figure of an underground mine is you can see a big that a headgear. And then, the cage is there and the cage this is a is the people how they go down there.

If you have read Emile Zola's this is novels, their mine in those days also the people were going down into the mines with a cage. And there were of course, in some of the graphite mines in been in India with that in the bygone days, they used to use the child labour. They used to take on a rope and on that rope and a basket on that a small boy will be put, he will go down and then the graphite will be mined. In that is the way, also the in the days of manual mining people used to work.

So; that means, you can take the material on a cage or sometimes there is a another varieties is called your skip. There is a container which will be taking in say in our copper mining in this Mosabani and all, they used to have this skip taking out the that copper ore from your underground mine there were a system.

So, this skip and the cage they are hoisted by a that means, from the ground through the mineshaft, they will be having a winder; a winding engine. So, in the mine transport, this winder and winding engines and how they will be doing safely, those are there.

Other than that, there are sometimes scraper haulage or slusher. You can just scrap the material, bring it up to here and give it on a chute; from there the material will be going. So, there are also cableways chutes, gadgets, many other type of systems are there.

Now, in the continuous system, basically you have got that in metal mine, you will be finding ore passes or the chute the material is brought and then, they are just allowed to flow through the chute it will going. So, no other machines and everything is required. It is just a porpoise things will be going like that.

But there are continuously the material is moving in a chute. Similarly, that in a conveyor belt, in your that conveyor could be a vibratory conveyor, it can be a chain conveyor, it can be your this that your cable belt conveyor. There are so many different type of conveyors are there.

The belt conveyors as a continuous system is very much used. But this endless rope haulage is also a rope is continuously moving. And then, your tub is connected over there and it will be going.

So, that is the carrier that is your the attractive motion that which is carrying that is continuous, but the material is going batch by batch. So, that type of transportation systems are there. So, then sometimes this your endless chain screw conveyor is another type of conveyor, it is used. Just like auguring, your that material you have seen when a carpenter make your auger, what happens?

It auger goes in and the materials comes out, now you think of that one, if you are having that screw horizontal and keep it rotating; at one end, if you put the material, the material will be going out in the other sides and its exactly the same principle for carrying material even upward. You might have seen the Archimedes screw, where the water was to be taken from a lower level to the higher level by just only making a screw to move.

So, that screw conveyor is another type of conveyor. They are used in different in particularly in some of the processing plants and all, you have got these use of screw conveyors. Then, another thing is there that your you can have a fluid suspension; that means, you can make the things to flow float that is your in a slurry, you make with water and pump the water as a slurry from that is that what that is material in water will be carried.

Sometimes, it can be in a pipe. You just make that air to suck it and then in that air, you can give the powder, you take it and then, collect it. So, that is if your material is reacts with water, you can make them to float in that is suspended in air and then, make through a pipeline, this type of call your pneumatic conveying. So, there are different types of conveying system which could be used.

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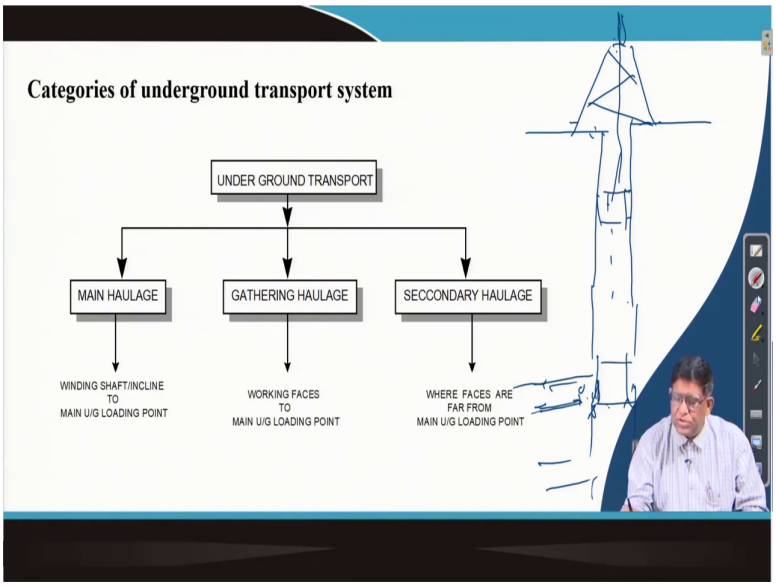

So, basically your underground transport system could be a main haulage, a gathering haulage and a secondary haulage. Haulage; that means, hauling taking the material from one place to the another. Now, main haulage when your the from that if you are having an underground wounding shaft, from that shaft you are going down.

So, basically what is there in your underground mine, you can see here suppose you will be having a shaft like this, you may have a that is your normally a big shape will be there and

this is a structures from here, you are suspending a cage and it is going down. In the down underground mine, there could be different level and from different level, people will be coming and then, they can enter into this cage.

So, this these things when there is coming from that to your main winding here, then it is coming over there; if it is that there will be a cap gear on which this case will suspend, the door will open, the pop person will be coming out and then, from here, it will go to the that your mine phase maybe different distance. So, these type of systems are there in a main haulage.

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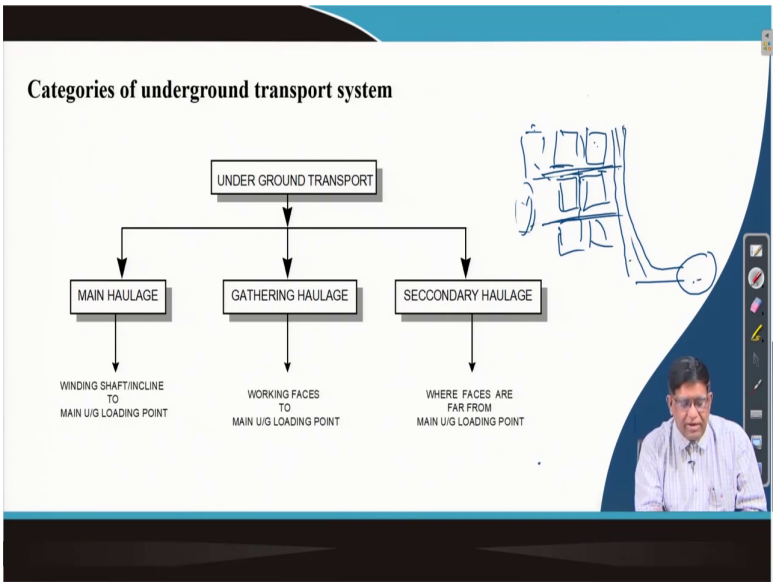

But then, other is your gathering haulage, what happens? That is in your any underground mining, basically in a bord and pillar mining, what is done? You may have a number of these are the coal pillar. Suppose, these are number of coal pillars are there and then, we are having

this galleries and then, from here, the coal when it is cut collected over here and there could be one main hall road, this is going to the main shaft.

So, from here, we are having this secondary haulage. From this area or in underground mine, we say this is a district. Now, these are all coal pillar. In between, there are these are the roadways connecting to the main road. So, this is your main haulage here, we are having the gathering haulage.

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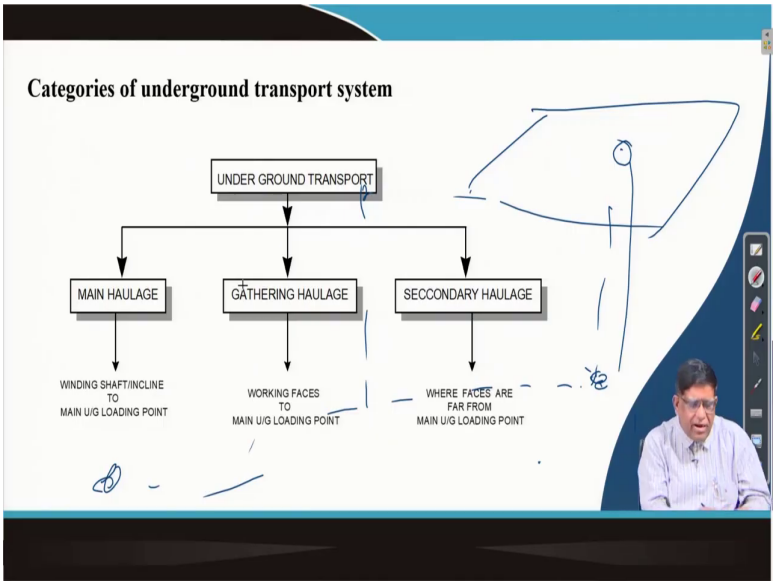

So, there could be different type of systems could be put in underground for bringing like that. Then, when this your in what happens? You have gone down into the surface; say for example, if this is your in a surface you are having this is a mine open over here.

Now, when you go down here, you are coming over here from there and then, you will be travelling into different distance and then, you are doing the mining over here and here. From there, you will have to come down below and then, come over here.

So, there, there could be a secondary haulage. From here, it will be going and connecting to a road, something like that exactly you are coming from your village one particular this and then, you are going to a [FL] and from that one.

You are going to the main road and from there, you are going to the trunk road, like that. That whole that road network system is also done in an underground and there, where you are working in a smaller area, there you can have a secondary haulage.

So, basically what is there that the way you are having you have seen your city roads and then city road going to a small town; from the small town, you are going to a village; from the village, you are going to then different that [FL]. Similar ways, we will have to have a road network, which are called your exactly you will be telling in underground mining methods, they sat it is a gallery.

You will be having the different galleries through which, we will have to make that your air to move and then, which way your material will have to go move. Because you will have to take care of your road and that transportation route so that your that how the ventilated air is going over there, that airflow can go up to the face, where the workers are working.

So, that is why in when you talk about the mine transport. We will have to know about the mining method by which it is being done and there which type of machines will have to be used.

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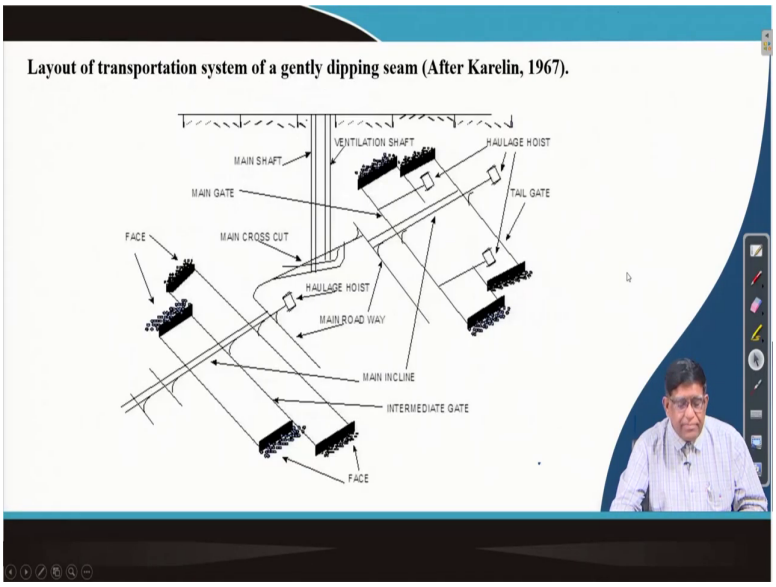

So, then, you can see here this another figure which can give you a total overall picture of the main layout, that is you can see here this is what we are telling as a main shaft. From the main shaft, it is coming and then, there is a main cross cut. It is a main gate, you can see here this is a haulage hoist is there; that means, a haulage hoist means a rope drum is there.

A rope will be going and connecting from these ones, it will be bringing over here. So, this is another haulage hoist, there will be a tailgate and there is a main gate. Similarly, this is a working phase from here, these are all the your that intermediate gate and then, their work is coming. This is the main haulage; one hoist is here, it will be bringing out all the tub up to here.

From there, the tubs or carriers, it will be brought by manually, it will be pushed over here to a cage and then, it will be lifted over here. So, that is where how exactly the underground

mine; transport is done. So, so far you have now learned that a in a mine transport system, we are wherever the phase; that means, where exactly we are loosening the rock mask to be and that getting that bulk material.

From that bulk material, you will have to have a means to load it to a transporting unit that transporting unit will have to be hauled over a trap or by a tire mounted machines. And then, those small that is your car on which the material is collected are brought near to the shaft bottom.

Shaft bottom means that in the in that shaft bottom portion, you will have to make a proper layout so that this strange of mine cars which are coming over there. They can rest and then, one by one, they can be pushed into the case and then, case can lift. So, this is what is a mine transport system as such.

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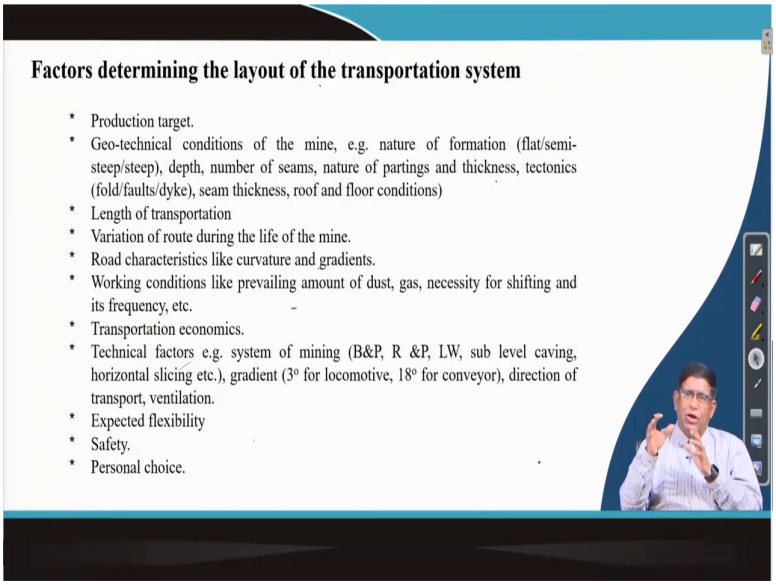

Now, what type of machines will have to go for that? When we say for that this how before going to the machine, you must know that what are the factors that will determine the layout and the transportations layout of the transportation system? As you can easily think, it is just only a matter of your practical thinking that is your production target is definitely, your if you are going to make a big 5 million tonne mines or you are going to have a 0.5 million tonne of mine, depending on that, the layout will have to be the equipment will have to be selected.

Geo-technical conditions of the mine is very very important. As a mining engineers, you know that how your coal or the ore is there whether it is you are working on a lands of thin or you are working on a seam as a flat deposits like a cold seam. Then, it could be a steep incline seam; it could be a very thick; it could be very thin.

So, depending on that, the geo mining conditions and then, also that whether this between the seam, there is a parting. That means, whether there are a lot of the inter burden is there or not, then what are the thickness. And then if there is any geological disturbance.

Because if there is a fault or a fold, these are the terminology you know as a mining engineer that will have to be taken into consideration in designing the system for there. Similarly, that what is the length of transportations. What are the variation of route during the life of that mine because the mine is expanding and going to different districts. Then, from there, you will have to see how the distance will be changing.

Whether you are doing if you are doing a long wall mining; whether you are doing by returning method or in an a advancing method, depending on that the transportation systems will be different. In some cases, you will have to first do the wall capital investment to do a long that conveyor belt and then, you will be going coming down and cutting that or reducing the length of the conveyor belt.

If in an advancing method, you will have to have the go on increasing adding and doing a lot of vulcanizing during your production phase. So, there are different way how we will have to

select it. Then, how many curves of the road, it is coming from the in underground also, do you have to have a lot of turns and round around.

Then, what is the working conditions there? In underground, definitely it will be a very dusty; but in that underground mine, where you are working in some of the mines a lot of water will be coming; the other day when I was going to that in Gumgaon that in Nagpur, manganese ore mines, miles underground mine. There a huge water you can see that just like drop rains, it is coming there is a high water percolation is coming.

Similarly, that means, there the transportation system will have to take care of that. Similarly, your most important thing is the transportation economics because dust, gas your how many times, it will be shifting and all these things; they will be affecting your economics; whether other things need to be arranged along with your transporting.

Then, technical factors; whether it is a bord and pillar mining or room and pillar mining as they say or longwall mining; whether it is a sub level caving or a horizontal slicing or this depending on that what gradient to use your locomotive, you requires a flat gradient.

If you are going to conveyor up to an 18 degree, you can go sometimes. Then, in which directions, you will be doing along the ventilated air or against the ventilated air. Those are the technical matters you will have to see along which what will be the capacity, how much will be the exactly rate of travelling and those items will be designed and then, that equipment will be selected.

Similarly, whether you need to have a flexibility; that is, it during your life of the mine you will be going on changing the technology for doing or you have done 50 years ago that rope haulage was there and it is still continuing because we do not think of any flexibility ok, our rigid this is there [FL] if you want to do it like that, you do it.

So, that is most important is safety; [FL] safely [FL]. So, that is why your safety is very very important and of course, the personnel choice. If you are a private mine owner you want that in your mine, it will have to be the state of the art technology; you can do it very good. But if

you are going to ok, I am making money, it is alright, workers [FL] and then, it will be done like that.

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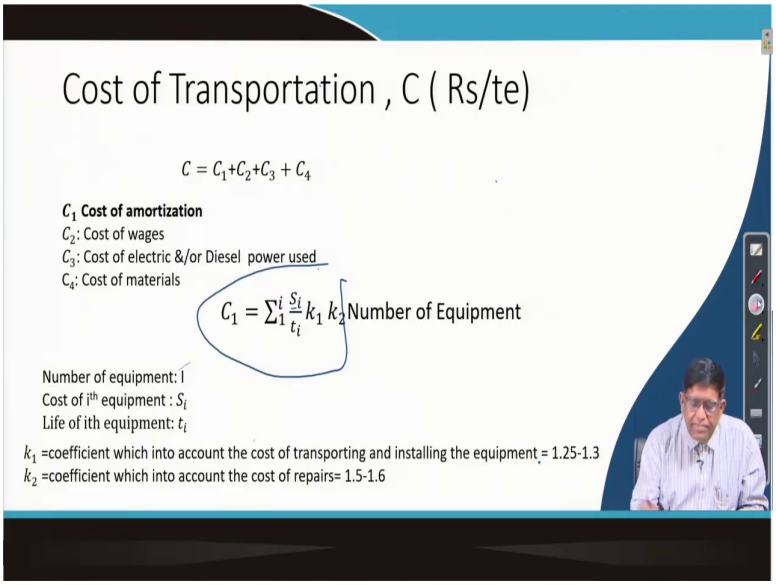

So, then you will have to get this cost of transportation, you can find out. This cost of transportations can be calculated in terms of four factors; that is your cost of amortisation, cost of wages, cost of electric and diesel power and cost of materials. You can easily find out this a cost of amortisation.

It will be depending on what is the cost of i-th equipment and then, life of that i-th equipment and then, how many what is the coefficient into account of the cost transporting that to the installing equipment, that is your the that cost of transportation and installing the equipment, there is a factor and also with the how much repairing costs will be coming and then, what is the total number of equipment for i-th number, then when you will be this is your this number

of equipment is exactly the i which is written over here. This is, it is. Do not take into it. The C 1 is this formula.

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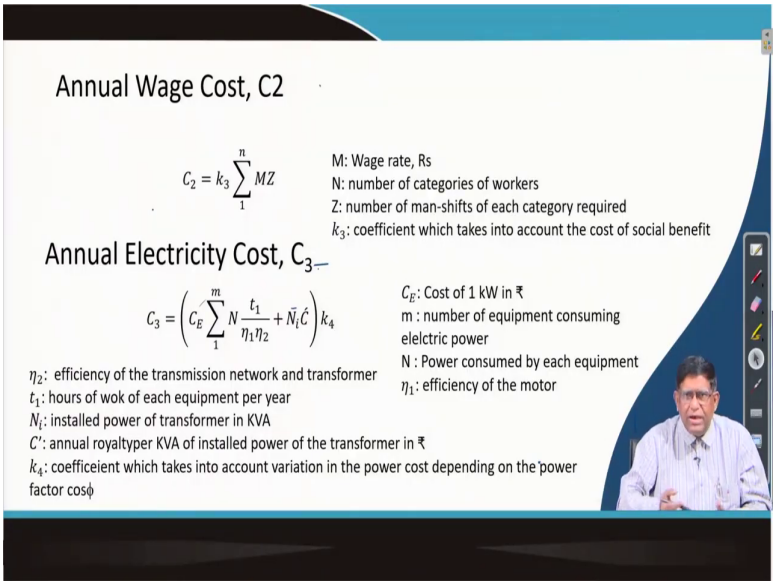

So, you are you are considering this is your cost component, similarly you may have this other cost also, you can calculate it out by these annual wage costs. You can find out the annual wage cost by this formula depending on what is the wage rate and how many number of categories of workers are there; how many workers are there. And then your if you are to give a social benefit, those things you can find out.

Sometimes, you can formulate that formula by whatever the condition existing. Only you will have to take it. The annual electricity cost that also for each and every component that is what is your exactly the tariff of that particular area and that is your the rate that cost per kilowatt.

If that is known that C, then that will have to be multiplied by the that what is your total install power and what is the transformer. By this way, you can do a calculations.

Now, this equation is a giving as a generic equation, but you can whenever you go to any practical training or any visit of a mines, there you can find out in which way they are doing and or you can start doing it. Why I am doing it over here? That is, your technology or innovations will be coming, it is a it will be demanded when you know that it is just exactly there is a wastage of money.

You may find out that your electricity costs will be much more than when there you can save by putting a change in the system either by equipment or by the way of working over here. Similarly, you can sometimes if your cost factor is coming in ways, you can think of how those people can be they deployed so that with the per person the productions come more.

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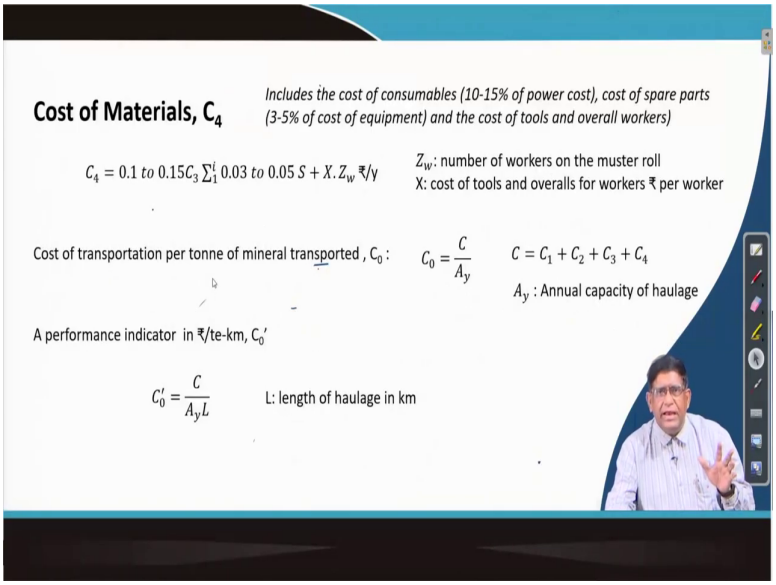

That is what also is a better that is why in a technology you will always have to get this. Then, the cost of material this is exactly depending on that is your how many number of workers are there on your roll and then, how much material exactly you are transporting. So, this whole thing once you know the total cost.

Then you can find out what is your performance indicator as a KPI that is key personality of that indicator will be your how much rupee per ton kilometre of your transport. Once you find out that, you can find out, you can compare; [FL]. Then you can consider a technology evaluation technology assessment and then, you will be going to notice.

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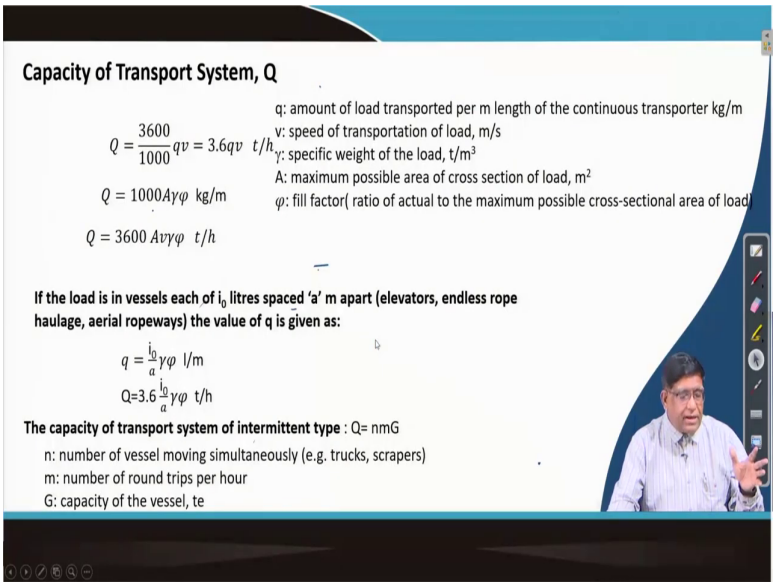

So, coming to this that capacity of the transportation system is very important parameter, you will have to determine this inconvertible calculations, we have said that compare capacity is a volumetric capacity or in a ton capacity, when you multiply by the density. AV gamma; A

you know, this is that exactly the maximum possible area of cross section of the material on the conveyor belt, we discussed that one.

Then, you can find out that is your if the load on a particular vessel or the carrier in a mine tub or car, if it is a you are a i 1 litres and if these two are spaced at a distance of A, then you can find out what will be this capacity coming in terms of their spacing over here. So, this is just only a common sense equations, you can put and then you can calculate whether it is an elevator; whether it is in rope haulage or whether it is in a real rope way, that same formula can be used.

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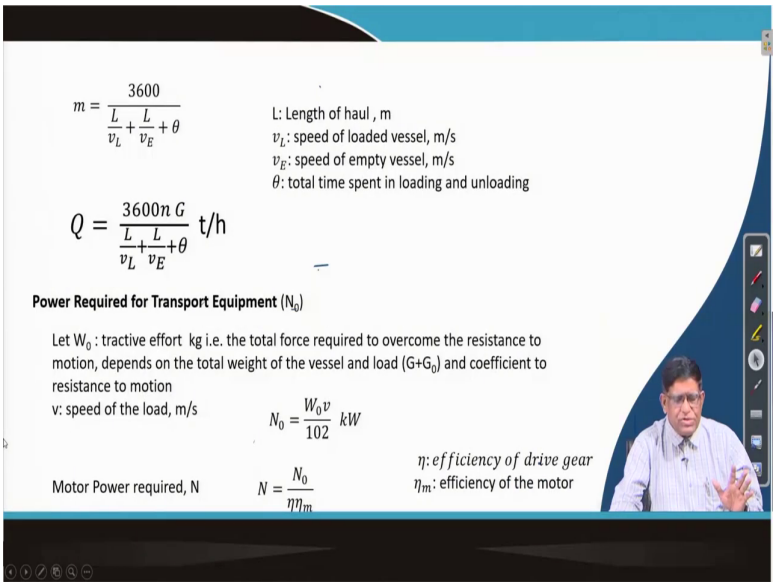

So, once you start doing this generic things, then you can find out that how your this capacity will be depending on your length of hole and then, your what is the speed of the loaded vessel is going and when the speed at that empty vessel is coming. And then, your let a load empty

vessel to be connected to the return tabling unit or the loaded will material will have to be connected to the rope that, that exactly the time which is spent that will also affect your productivity.

So, your if every unit whatever you are having, if this is your the depending on the total number of units and how much they are carrying, you can find out this calculation.

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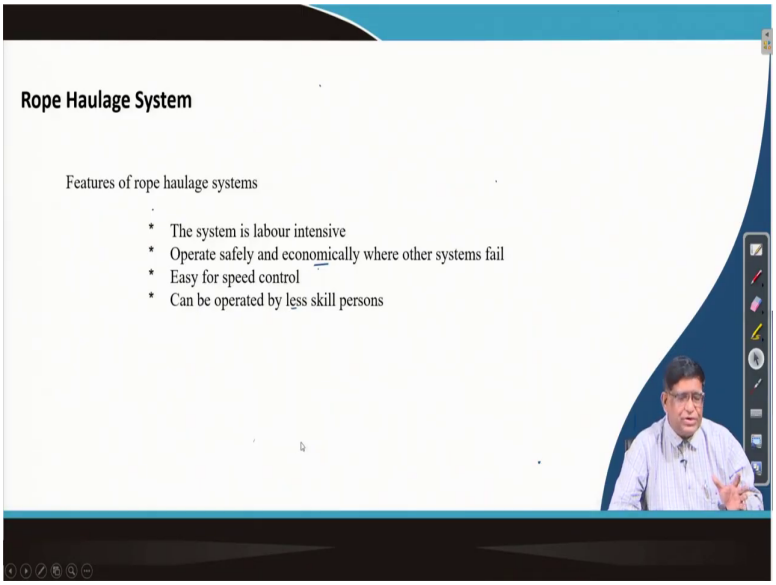

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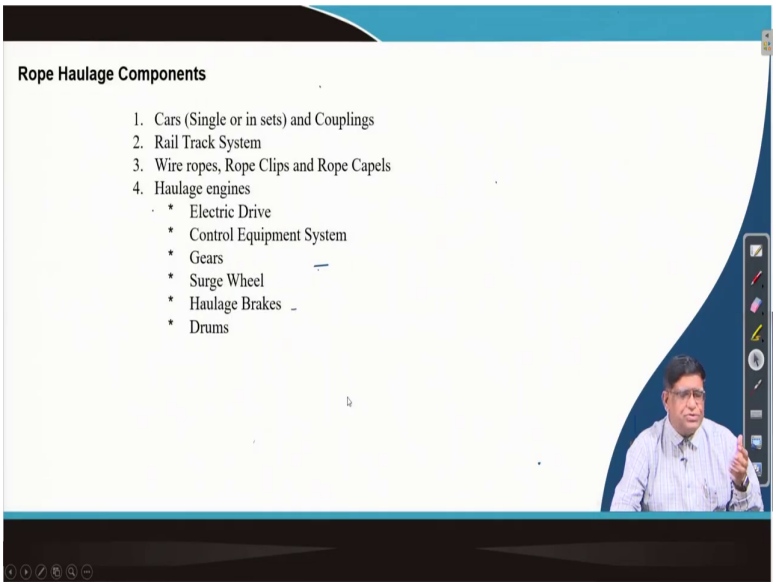

So, these type of systems are there and in the mine, you will be having this rope haulage system which is very widely used and this system is a very labour intensive, a lot of people are used; but in a rope haulage system, you will find there is a car. There is a rail track, there is wire rope and there is a haulage engine which is a very basic simple is a engine with electric drive and control equipment gears, surge wheel, haulage bridge and drum. We will discuss about these units how they will be there.

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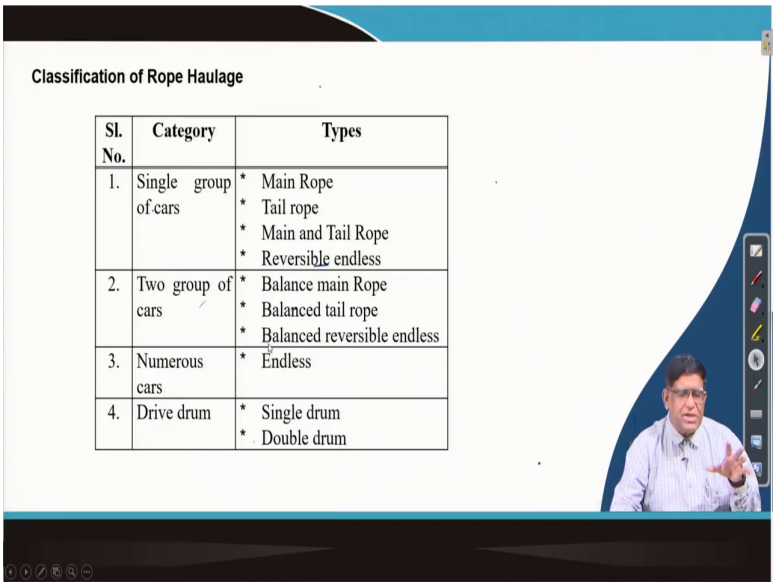

And then, how different type of haulage are there that is your main rope haulage, tail rope haulage, main and tail rope haulage and reversible endless haulage. Now, there could be a balanced rope, there is a balanced tail rope and balanced reversible rope haulage and there could be a number of car can be connected on an endless and that can be driven by a single drum or double drum like that is there. So, you can read any mining engineering handbook, you will find this is the system over there.

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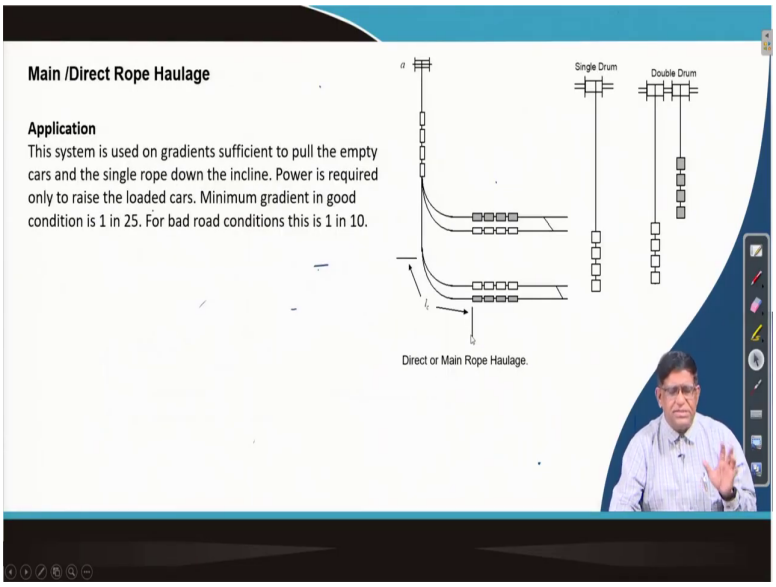

So, in a direct rope haulage, this one drum, it is carrying. This is a trait number of cars are drawn over here and this is way how a direct haulage work. This form a single drum, you are just carrying it up. If you put a double drum, your empties are going down and as your loaded are coming up or the vice versa, you can make arrangements with this.

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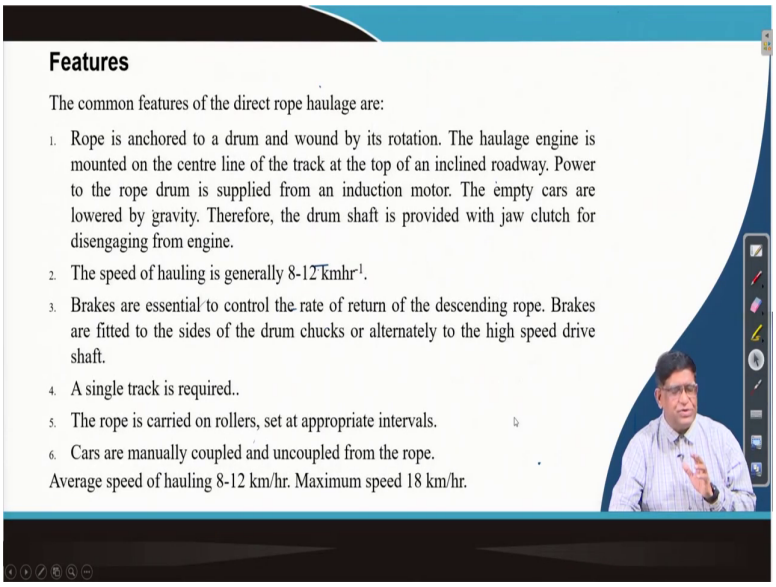

So, you will study about this main common features that is your how the rope will have to be anchored on a drum and the other side, it will be there with the cars. And that will be moving over a track and that speed will be about 8 to 12 kilometre per hour.

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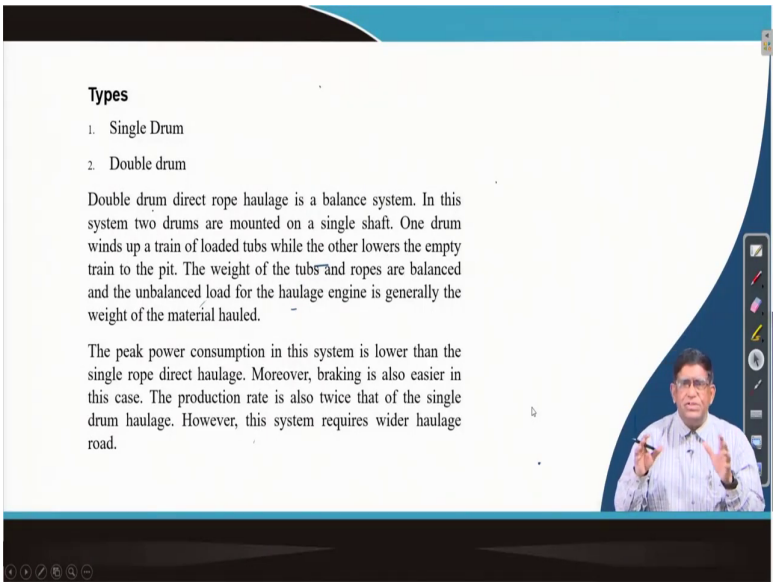

So, you will have to have a break arrangements and then, how on the track will be laid and what are the different safety devices will be there, that will have to study and then, as I have said already in the diagram. It could be by with one drum or double drum depending on that we can have a balanced or unbalanced systems.

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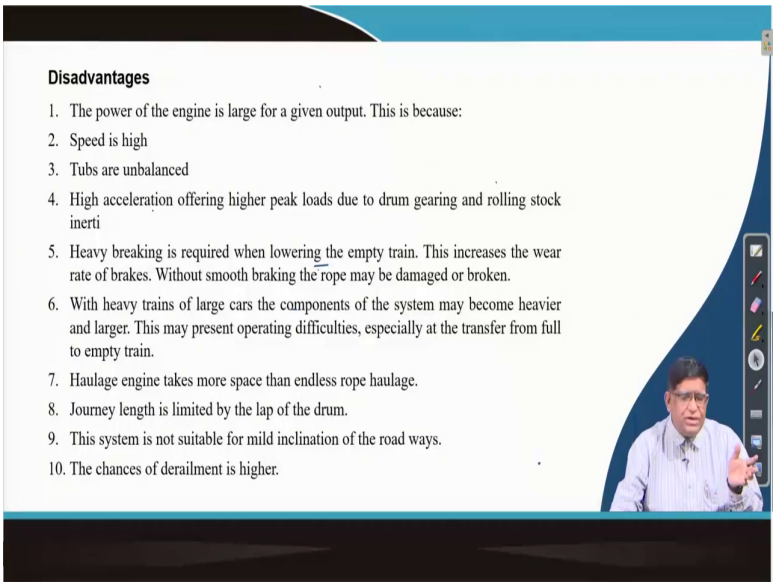

So, there are some advantages as it is very simple, it can be easily installed and then, I can be worked way unskilled people also. But the disadvantage is there that is exactly the power of the engine is large for a given output. This is because of the speed is high; tubs are unbalanced and then, the high acceleration offering, high peak loads due to the drum gearing and rolling stock of inertia. So, these are the some of the advantages and disadvantages you will find.

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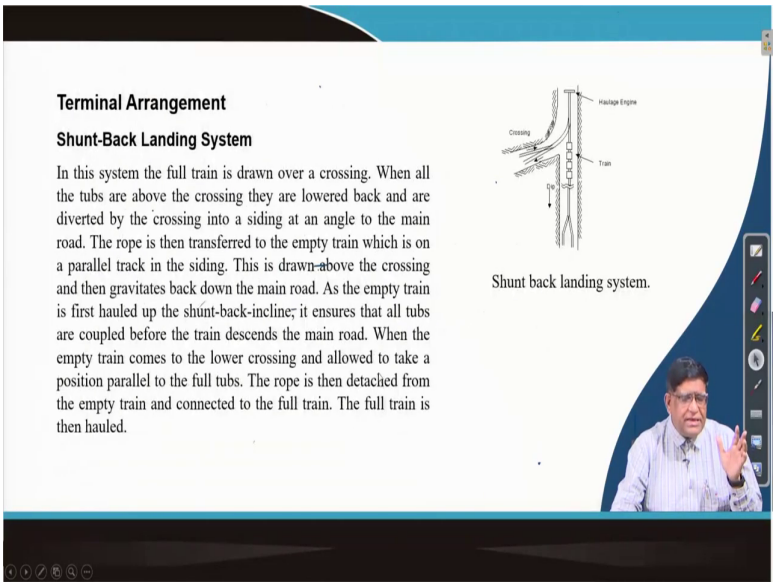

Now, how they are arranged in an underground mine, we will be discussing rope haulage in our next discussions.

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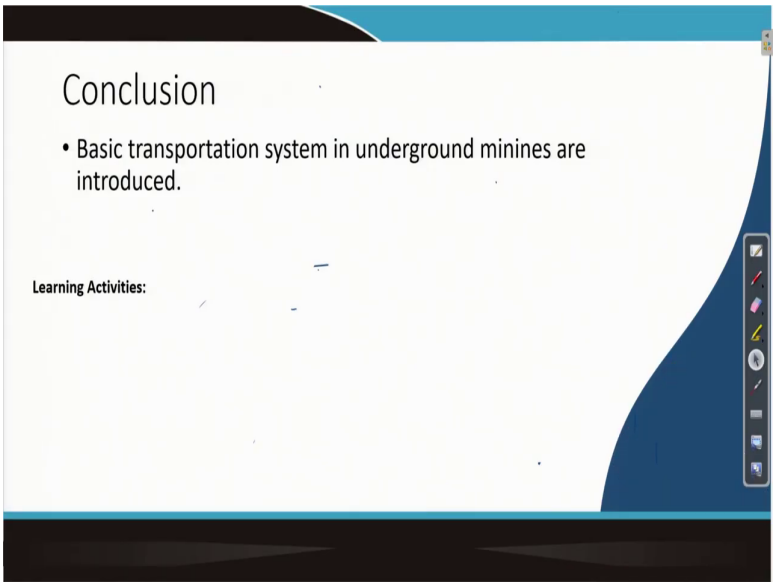

But what is there as a I have introduced here, the basic underground mine transport system. We will be discussing the machine spot a part and there what are the basic mechanical engineering is involved and what is the basic electrical engineering is to be known, that will be just simply highlight in our upcoming classes.

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But as a learning activity please make a note on that is a what are the different type of underground mine transport system. Please prepare a general knowledge type of presentations by yourself. And for that, there are a number of resource materials are there.

Please read; N. T. Karelin and number of websites, it is available; references are given. And then, you start doing some activity for doing a presentations of different type of underground transports machinery, machinery for underground mine transports and we will be discussing one of this equipment in our coming to three classes.

Thank you very much.