Bulk Material Transport and Handling System
Prof. Khanindra Pathak
Department of Mining Engineering
Indian Institute of Technology – Kharagpur

Lecture – 54
Introduction to Cage and Skip Winding

So, welcome students. Today we will be discussing another aspects of underground mine transport. That is the winding operation. You know those who have seen any mines or those who have ever been any opportunity to see some films on mining or videos on mining, particularly underground mining. You might have seen the materials and man they are being lifted within a cage.

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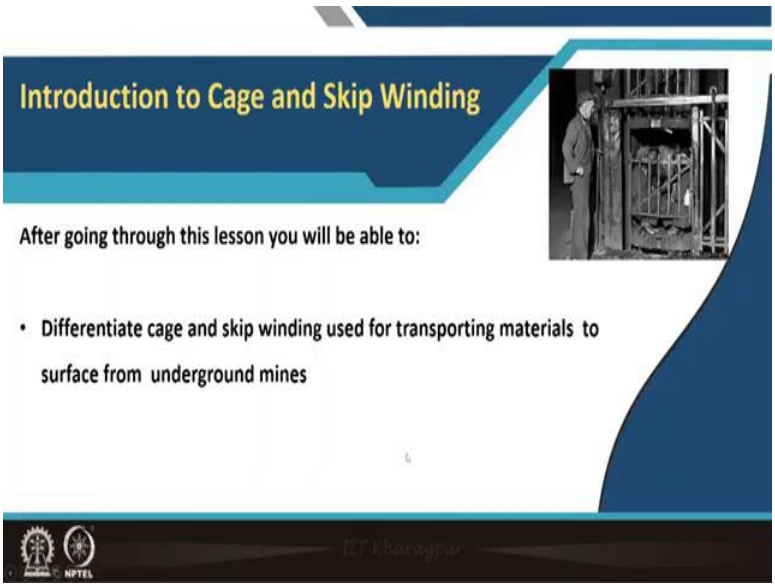

So, as this picture which you are seeing is a very old picture almost a signature picture for underground mining where that cage within which this people were brought or the materials loaded in a mine car are put inside the cage and then it is lifted to the surface. So, depending on the container by which the material is brought up or the arrangement of the system, we have got two distinguished systems called cage winding and skip winding.

So, this, today, we will be discussing about what is this cage and what is this cape. And how they are exactly placed in a mining shaft and how that whole when winding operation are carried out? As such this whole winding operation, their calculations, their design all is a vast area again. But here our purpose is to understand the basic of it what it is? So that those of you who are interested can take up some work on it.

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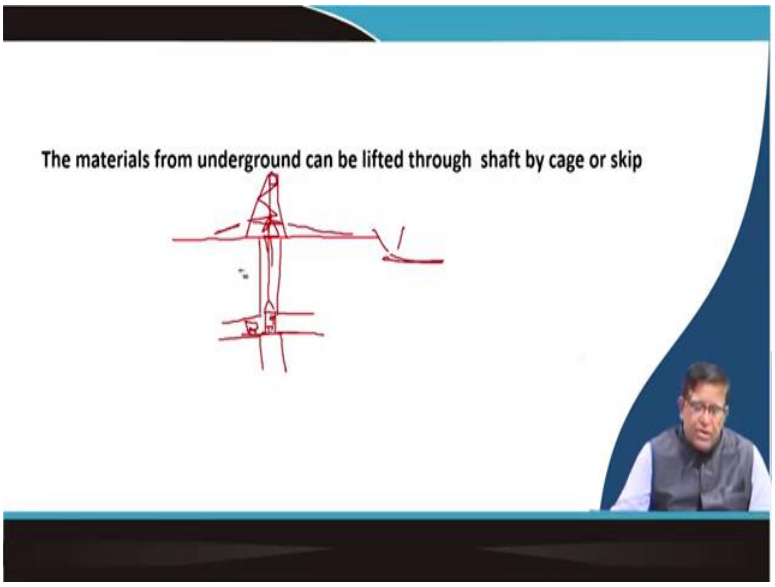

So, this introductory lecture, let us try to see what is a exactly this widening. You know that these materials from underground they can be brought by this cage or skip. Now, you know that whenever there is any underground mine suppose this is your surface. And then you want to that may be you are having your coal seam somewhere that say if your coal is lying at a depth somewhere here, it may be lying like in a coal seam.

This coal is lying over here so, normally what is done in your method of mining? You will be knowing about it that we can go vertically, we can access. You can have a vertical access to this speed that is called your shaft. When you make a shaft then this one, if it is shaft is going through this then you need to get this coal from here. You will be making some horizons. So that means what is done here exactly you can see that.

Basically, you are having this shaft which will be going down here. This shaft will be going down like this and then from here it will be going entering into the mines. That is where there we are telling these are the roadways or gallery or drift that will be going over here. At the top of it will be having a structure called your headgear structure. In this headgear structure will be having a sheave.

From there we will be lowering a winded rope and then we will be suspending a cage or skip over here. Now, when this cage is coming down here then, from here this part will be connected with a tray rail, it will be connected from this side. So, the mining car which has

been brought here by your rope haulage or by locomotive haulage. This car will be pushed and kept over here or the people who ever want to go that persons also can come over here.

And then it will be lifted and from here when it is coming up to this level from here. It will be taken up through this and then you know that in the pit of layout, where this car will be going. And then suppose they will be giving to a hopper from here, it can go to a conveyor belt or it can go to this to the users. And this car will be returning back to these portions you may have a creeper over here.

And then putting the cage again this cage which was here it will be lowered down and this will go on. So, sometimes instead of this cage, there is a skip which is a container. This container will be taking the material from underground directly into that skip and that skip will be that will be brought to the top.

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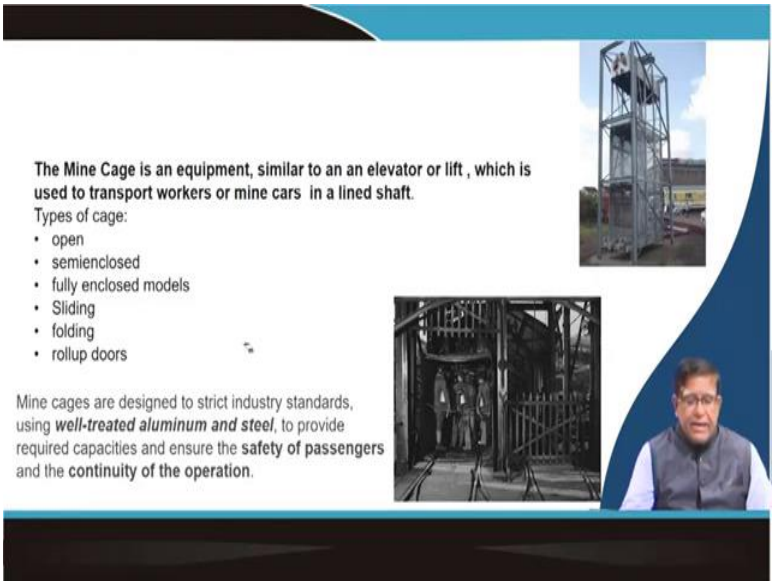

So that means your this you can see here that my cage, this figure which you have seen over here, this is a cage and that cage it can be number of decks. So, this is a triple deck that your double deck cage over here. So that you can just below this another layer the people can be in both sometimes in one layer you can have the person standing another the car standing and the whole thing will be lifted.

You can see this tracks are laid so that when the mine cars are coming, they will be putting over here. So, these cage the locations they are exactly in within that now this they are being suspended by the wire rope and a suspension gear over this vertical shaft. If any snap stick

that whole thing will fall down. Now, here you can see this cage part it can be of different type.

It can be an open type, semi, enclosed type, fully enclosed type, sliding type, folding type, roll of doors that means, depending on this is a that particular location of the mine, what is their technology available? What type of materials available? They will make it if you see in 18th century, 19th century, they were made all these things with wooden cage and they started dropping them by manual rope that was a starting of the industry.

And later on they are suspended by wire ropes and this lot of technological development has taken place. And this cage which can be now with a well heat, treated aluminum and steel that is giving a sufficient strength, it could be objective will be it should be as light as possible. At the same time, it should be the strength as required for with taking the load and because the one of the most important thing is we will have to optimize the energy more heavier, more weight means to lift and lower you will require more energy.

So, you will have to see that, what is the minimum weight of material required to make the cage. And also that the cage suspension how you are exactly on the rope you are suspending. That is very very important as a safety. At the same time, when you do all the mining engineers they study this winding system and their safety arrangements very carefully because this is the exactly the lifeline of an underground mine. Because if the winding system is not working you cannot produce.

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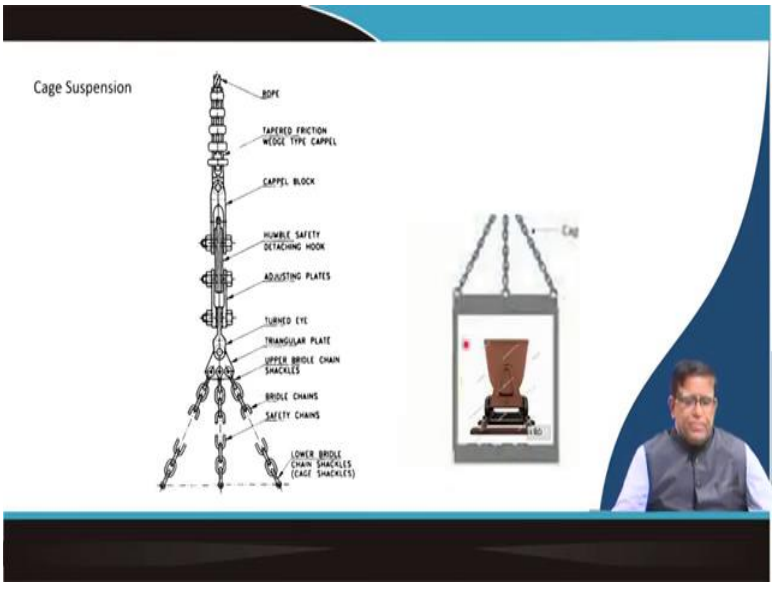

So, here this cage within the cage you will have to have the mine car and then will have to suspend it and then it will have to be lifted. So, there is a wire rope the steel wire rope which is in the rope haulage and all also so, this wire rope will have to be connecting to this cage and these are the suspension chains. This suspension chains, they will be having a shackle on which this cage will be suspended.

And then there will be a triangular plate which will be connected to a turning eye and here there will be a safety hook. This purpose of this safety hook is, if your because this wire rope, this wire rope will be going to a drum. Winder drum where it will be this exactly at the your whenever your rope will be coming like this. Suppose this is your sheave from where you are suspending the cage here.

Now, this wire rope, will be going and then it will be wound on a drum. It will be wound on a drum and there will be number of turnover rate depending on the depth of the shaft. Now this wire rope now when it is going suppose when your this is driven by your this motor, this winder drum will be it is mounted on a ground or maybe on a tire and it will be coupled with a gearbox and then it will be coupled with a drive motor.

Now, if this motor is control is not there when you are winding then if your brake is not applied or the brake is failing then what will happen? This whole thing will be going and that sheave where the sheave is mounted at that point it will hit. So, at that time there will be a disaster with such a momentum if it hits it will break down and that is why what is done? This safety hook, there is an arrangement that when it is getting over winding like that at pipe arrangement, with this hook.

And a safety plate that rope when it will be passing a particular area over this, when it will be going a particular level, this rope will be going. They will allow the rope to go but the cage will be kept suspended over here by this safety plate. So that the cage do not fall because if the cage get it falls then it will be going down to the shaft and that will be a disaster. So, for all this reason, what is done that you will have this suspension gear which is having this?

As I said, there is a safety arrangement. At the top of it that rope will have to be terminated to this through a couple block and above here the rope is terminated with a wedge type of capal. That there are different types of this rope termination system that is white metal capal which

cable that your this thimble capal. That depending on that these arrangements are made so that your cage is suspended.

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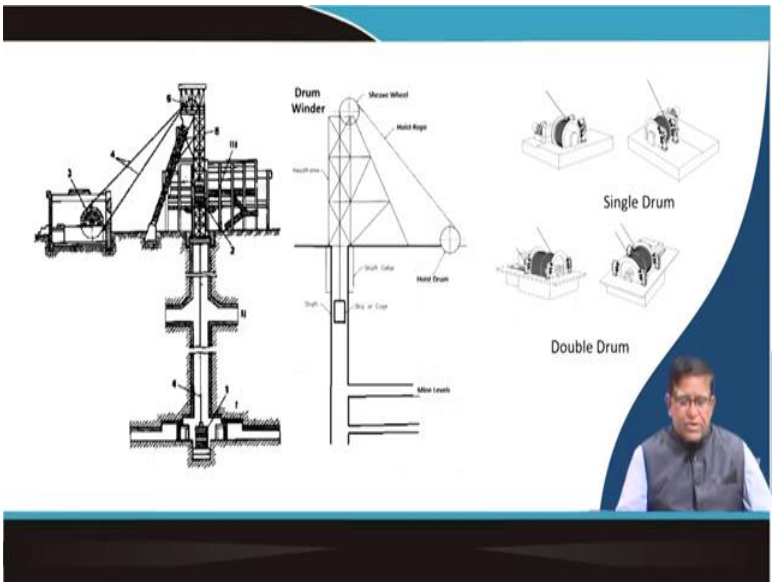

Now that suspended cage is can be brought within the shaft. You can see here in this diagram that your cage is suspended with this wire rope which is coming to your this bunk level, where there will be the cage. From the cage the your mine car will be taken out for dumping the material for the next transportation. And then there is a level to which there will be the safety hook and other safety appliances will be placed.

And this sheave is mounted over here and this is the drum over here. Schematically, you can see this drum winder. This drum can be a single drum or it can be a double drum. In the double drum means, there will be two rope one that means instead of one cage, we can have a two cages and one the loaded one when it is coming up, the unloaded one will be going down as because both are connected to the same shaft.

So, there will be some power balancing that means because that one which is going down it will be exactly also helping in getting this your loaded one to come up. So that way, we can have a double drum or single drum, winding system with a wire rope. And this is called your head gear structure. This is a back stay on which it is there, so that you can make it stable their design.

Considering all the wind load and structural load whatever is required and then we are having that sheave which this wire rope or hoist rope is going. So, this is a cage winding system in

which that cage which you have seen, is connected over here and from different level it can be collected. There are lot of technological arrangements are here for arranging the safety convenience and how it will be placed over here.

So that it and it will have a guide rope through which exactly this whole cage it should not suspend. So that the dynamic load will be increasing your this wire rope. It should be always with a proper tension. It should not kink and that wire rope damage should not take place. That is why there will be a continuous wire rope monitoring system. That if the rope is getting weakened, will have to replace it that what interval, how it will be replaced all are regulated by the mines, regulations and act.

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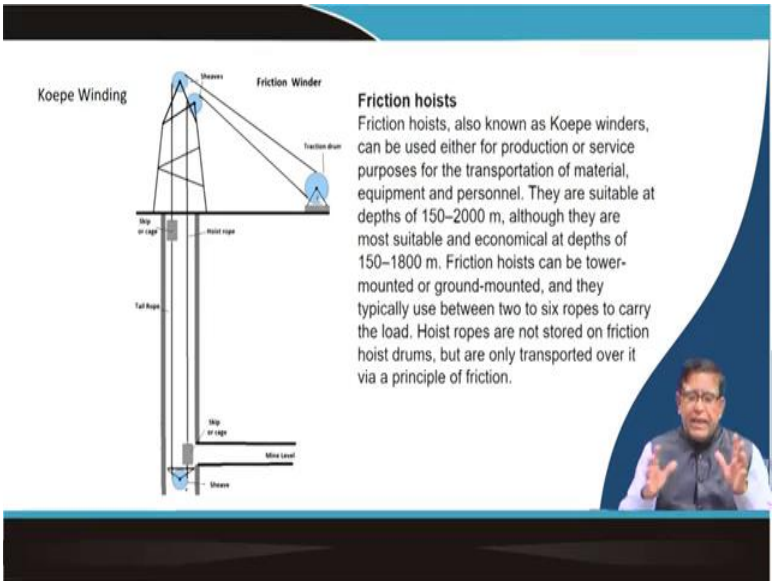

So, these are the things exactly you should keep it in mind. And that winding I have said that by a drum winder, instead of this, what can be done? In the drum you can see here that lot of winding of this your wire rope is here. So that they are wound and unwound and always you are keeping some rope over here. But there is another system in which you can see that this rope is continuously going and below it is returning over here.

That single rope there is no extra winding drum that extra rope is here. And this drum and this rope there exactly you are having on that friction you are driving this drum to that friction it is transferred to this system is called a Koepe winding or friction winding system. Only it is without having any turn on the drum, so, instead of a drum, it is a pulley. It is a rope and pulley arrangements.

And here that cage which is suspended or skip which is suspended at the back side there is the rope and this is exactly moving. So, this type of system here you can have they say one skip is here another is a here. Here this rope connecting them together is also called the balance rope. So, this type of system is also this is called a Koepe winding in most deeper shafts when you go up to 2000 metre.

At that time, this type of shaft is there. If you go say in Tata steels, Zamaduba mines in Besial, you will find a the Koepe winding is there. There are number of mines I think, even if in the some uranium mines, they have also the tower mounted Koepe winding system which is a very standard in the industry, those who of you who are more interested to it. You can study. You can make some case study of this lot of interesting each and every component.

A lot of study can be made out but you must know as such that is and what is a friction winding? What is a drum winding? And there the general purpose and description of the system I think you can describe it.

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Now, coming to the skip, now this skip you can see here it is unlike the cage it is a container you can see here it can be a small or it can be very big, it can be of two tonne capacity. It can be obtained on capacity depending on the requirement from here. Now you can see here that this skip which is this will be exactly suspended by the where winding system, whether it is a Koepe or drum winding that will be suspended from here.

And they will be guided by guide shoe rail or rope. And then they will be taking up, the material, material will be loaded, it will be put, it will be inserted through this point and they will be discharged from here. Depending on how it is discharged, there are different type of models of skips are available. So, in company, like F. L. Smith in India, they also supply, they manufacture it.

Now, these are some of the things why you should see the historically how it has come? And then we can think of how the engineers think for solving a problem where there is a difficulty.

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So, this type of devices were designed from the very primitive one it came. Say first Kimberley, a mines name only under that they have, they got an overturning skip. So, this keep is nothing but it has got a that you can see this side rails and then this one here this that you can see a modern F. L. Smith, this overturning skip over here now they have made an arrangement that the material will be loaded over here.

And then this loaded material will be lifted and when it come at the top, they make an arrangement that by pushing this, it can be given a overturned and then the material will be taken it out. So, this type of system buckets are very small, only nearly about 4 metre cube of material or as less as 1.32 metre cube of material it will be coming over here and then they are unloaded.

One problem is if the material is of sticky type and all that when you are taking it over turning all the material may not come out. So, then what will happen? There will be some they do it coming inside the bucket inside that your box and then it will be coming up. So, a dead weight will be there. So, your the energy, you are spending that your productivity that amount of material which will be lifting will be less that type of problem is there.

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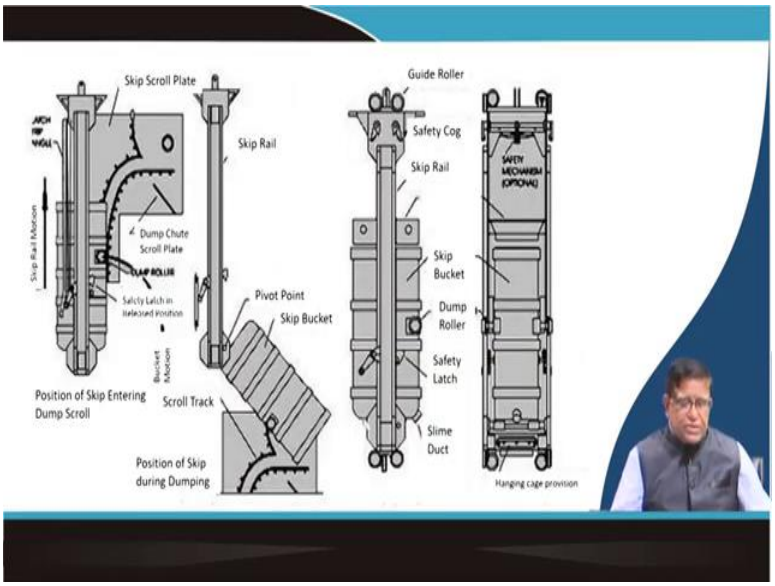

Now, this overturning skip there could be how you can see over here. There is a in the skip, a guide roller, a skip roll is there and then this bucket. Now, you can see by the side of it we have got this dumb roller arrangements. When it is coming to the top it will be brought over here and then, when it comes to the dumping point at that your skip roll plate here it get move and that whole meter become your upside down from this trinion point is here.

From the trinion point it gets and then the material goes out. This type of overturning this is skip. So, you can see that component wise this is your skip roll, here the skip bucket, here is your dump roller and you have got a safety ledge a placed over here. And there sometimes could be a slime duct. So, if whatever is sticky and all that thing wash then put it something you can open it out, the bottom portion also can be cleaned by the slime duct.

So, this is how, when is your skip, is going up it will be going like that. That skip has gone up over here and when this is coming up to this point, you can see it is over there. This skip roll it has gone up, now that skip is with the help of your this pivot safety latch is there. At this point it is getting detached and it is coming over here. Now, when this will be lowered down and then when it is lowering down like this, this will again become vertical.

And then it will be coming over here. It will go down at the sub or the inside the mine. Then again the material will be loaded from this top. So, now you have this is a how a overturning type of this skip works.

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Now, you can see there is a another type of skip that is your front dump in the front they have got a your hinge is there a door part is there it will be just from this door is closing system and the material is loaded and it is coming over there and then at the chest point they will be discharging like this. So, we can have different type of your that is your front dump skip or that their basic importance or the problem of this type of skip is because there is a mechanism, a liver mechanism, your spring mechanism which is working.

They will require continuous maintenance. If you do not maintain then their closing and operating will be difficult.

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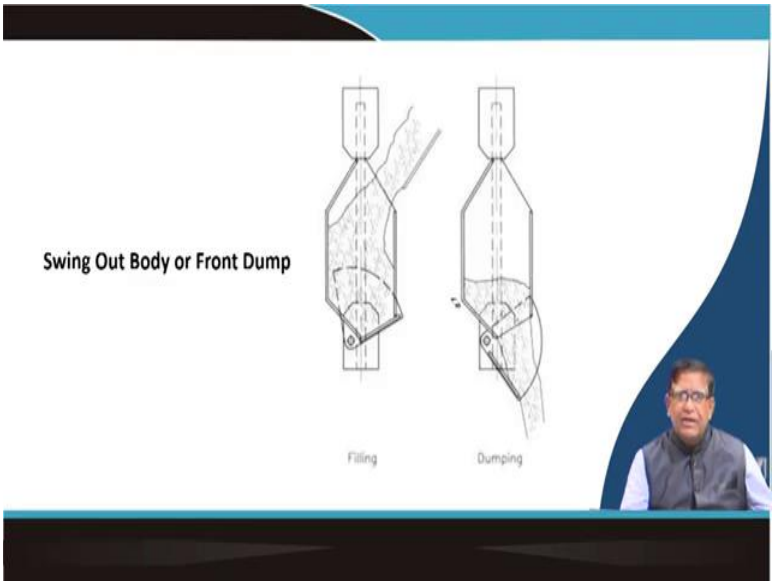

There is this your swing out bodies you can see here this is a skip bucket. Now, in the skip you can see when at the loading station in underground the material is brought inside this by means of a chute. Then, when the material is coming you are keeping your this sector gate of the skip is kept closed. Now, when they will be coming to the up at the your dumping position at that time, your this gate it will swing for opening.

And then the material will come out of it. So, this is that it is coming from here is a your sprout through which the material will be coming and material will be going like this. So, a mass flow will have to take place. We need to see that inside this surface sometimes if the material is sticky, you may have to keep a liner or so that the material flow well, as you have seen in bin and bunker discussions we made it.

So that your skip is a device which is going up and down the shafts but it is loaded there. Now, can you notice one thing here when you have used the skip you are using you are lifting the material only. But when you are using the cage all the time you are carrying out the mine car inside the cage to the top. So, depending on if your mine is to produce your 300 tonne per shift.

Then for 300 tonne to carry with those 2 tonne capacity cars, a large number of mine cars will have to be accommodated inside the gallery and then from the face you will have to transport. And then some of the mine cars will be always at the top and that is why total number of mine car required will be much more. But here that car is not coming up so, there wherever they will be going in the underground only to the loading position.

After the loading position, the only the material will be lifted. So that is why it is exactly capital investment. Of course, will have to see because this the cost of the skip will be more than the scope of the cage. Other arrangement is there but if you see the operational cost because of you will not require the many cars to maintain. So many people will be reduced because at that for the pit top layout you have whatever the manpower you are using that could be released.

So, those comes under your techno economic calculation or techno-economic model if you want to develop for the underground mine, you can consider that.

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Now, there is a also another call, your bottom thumb skips. This is another type of skips here again the loading is done and then from the bottom. That material will be coming out this one you can close over here at that when the loading position they will not be, it will be kept in a closed that when, at that your unloading position at the shaft top when it will be coming. This will be released through a lever and then we will make a shoot and the material will go out.

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So, similarly, you have got some arc gate. Here exactly you have got the the door which will be a opening and closing by an arc. So, this type of skips are called arc gate type of skips. So, you can see over here how things get innovated. That concept was there that there will be a container which will be loaded by material in underground and it will be brought now. You can imagine now that whether you can make a tabletop model if you are putting it there.

The material you are fixing how they will getting unloaded? How many whether it will be liver actions will be there or whether it will be a sensor electronically sensor, sensing and then controlling at in which way or whether can you for a sticky material if it is coming, inside cleaning, can you have an ejector blade can you use some hydraulic systems at that unloading system.

So that you can operate it to do the unloading operations very quickly. So that the cycle time required in that can be reduced. So, those type of innovations still can be there because how you can do the whole skip winding process as an automated one? Developing a simple that your tabletop model and that should be the spirit of all engineering students by just having this outlook and overlook.

Now, you should come, you should think of your take your autocad or take your draw works, bring up your this set scares and scale and pencils draw a schematic diagram. Think of how it can be fabricated. Do it over there. That is the spirit of learning engineering for developing things.

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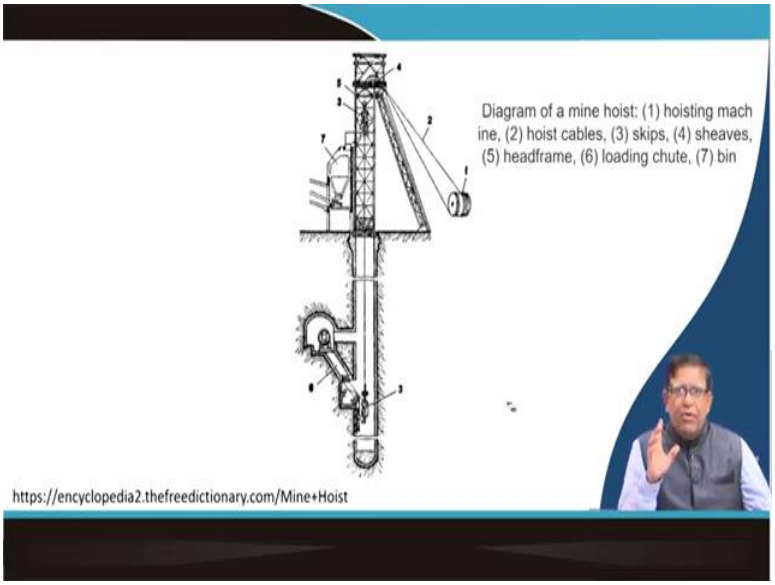

Now that skip if it is coming how you will be just like cage you have suspended there but in case of skip, you will have to make some extra excavation underground. Where that skips that mine car will be bringing over here and that tippler which was there for your in the in the pit top layout, I told you about a tippler where this car is tippled. Now that tripler will be giving to a bin or a stude here and the material will be guided to the skip.

As in the previous figure, we have said that skip has got a top where you can put the material down and once it is filled there. You can think of automatically it will be at that your gate it will be giving a signal to the winder persons, okay mera my skip is now fill. They will start winding and then the material will go up when it goes up it will be going up here, it will be brought and then it will release the unloading.

Maybe it is a bottom reacher from there. The material will go to this hopper below that we can have a conveyor belt or you may have truck by whatever way you take it. So, this is one simple system. Sometimes it may have got a different type of system in which in an it can just keep can come up and then it can go a little bit turn and from the top itself it can give unload the material and go. So, these also lot of options and can be innovated.

So, here the basic components of a skip winding system where we are having the main hoisting drum and that from here the hoist cables are there which is going to that skip which is connected over here. It is at the loading station. It is at the unloading station because the your in a Koepe winding one loading one is when it is there at the bottom. Unloading will be there at the top.

That is the length of the rope will be managed in that way, so that there is a proper positioning is done. And then this whole head frame or head gear is there and then we have got the loading shoot and there will be your bin. And the bin where the material will be given over here. So, this is the way you can describe now that what do you mean by a cage winding system or a Koepe winding system.

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Now, where it could be applied even in some surface mines also, instead of making your truck to move all the around that is ramp and all that thing they go over here. If your material is to be taken over here and from there you are taking that a rail or by conveyor you can take up from that bottom. You can load into that skip that skip can go up over here then give a overturn and then it will do.

So sometimes you can think of in some of the mines, if that is instead of travelling, say more than 3, 4 kilometer if by doing 100 or 200 metre only your depth of the open cage mine. You can have this skip winding system and that will be exactly making this economic. So, sometimes, whether in the mines, you can reduce the number of dump trucks which are required. If your that but only thing is there, you will have to have many of it.

Because if you are taking a say 270 tonne dump truck, you are applying in a very huge capacity of mines. There you cannot have this type of system but there are many mines in which our production capacity is less many of our that some economic minerals and some of

the queries where small trucks and all their diesel can be shipped. All things are with the technical feasibility and economic viability and need to compare.

And as a student, you should develop the econometrics model for taking out this after properly understanding that what are the technology involved. How much capital investment will be necessary? How much operational cost? And this normally in the final year, when you will be studying about the mineral economics, you should take this type of problem as your case study.

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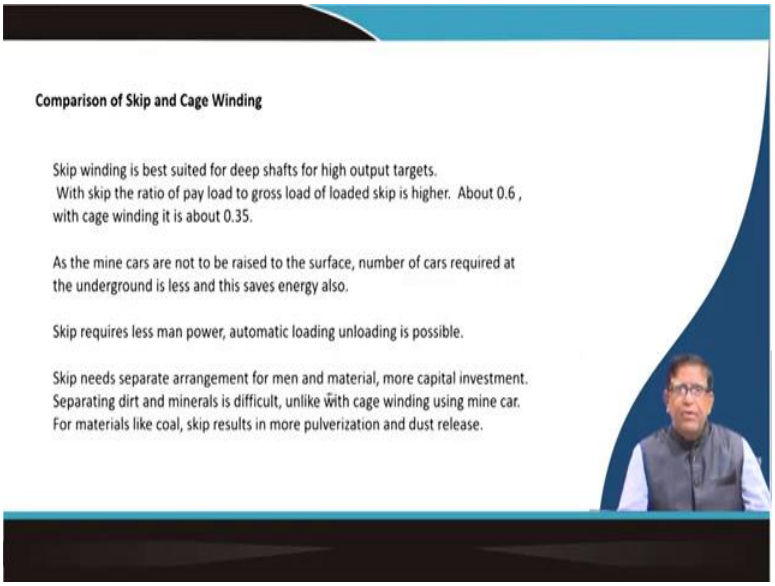

Now, you can think of when you compare this, skip winding and cage winding. So, as I said, the skip winding is best suited for deep shafts for high output targets which skip the ratio of the pay load to gross load of loaded skip is higher that ratio. It can go up to 0.6 in cage of your skip winding but in cage winding your that it goes up to 0.35. Because your that mine car it has get its own weight.

As the mine cars are not to be raised to the surface number of cars required at the underground is less, as I already told you skip requires less manpower that also I told you. And then automatic loading unloading is possible, so, you can improve the because of the automations you can get the cycle time is raised. So, exactly your hourly production capacity can be improved.

Then skip need separate arrangement of men and material, it will require more capital investment. And the most important difficulty or that the difficult problem is, if your mine

coal, if you are taking out by skip but in the coal seam there are some darts coming that band is there within the seam. Now, you cannot separately load and take it out in cage of your cage winding those dirt can be put in a car and then when they are coming at the stop.

In the stop those card can be separated out and you can easily unload to a dirt tippler. But here because it will be going in that same cage with the same systems that separating the dirt coming from the stream is difficult over here. So, another thing is sometimes with that skip when you bring the material while unloading they fall a higher the height is more. So, now you can find out.

That is exactly if, at the time of unloading material to material impact, as well as the material to the surface impact, they may get pulverized. If they pulverize there will be more coal dust will be coming up. So that area on which it will be there if you are not taking proper ventilations and all there could be a situation of coldest explosions. And also in the atmosphere those fine coal particles dust will be going that the persons working may be having the risk of getting pneumoconiosis. So, there are certain disadvantages as well.

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Which you need to when you want to go for a detailed study you should see over there. This subject is vast, lot of things are there. But I hope I have just introduced what is this cage winding? And what is a skip winding? Lot of informations are available in different websites. But I suggest you, read either Mr. Ghatak's book mine, pump, haulage and winding for

knowing about, how exactly the handling of liquid or this or solid is being done. Ghatak's book gives.

Or that Professor M. A. Ramlu's book of mine hoisting but that is published by White Falcon publishing, is a very good book, giving a very comprehensive and good explanations of what the technology is. So, if you are interested to know that what is that how material is transported from the underground to the surface? And this book I always refer that is the mine hoisting which is based on Professor Ramlu's experience in German mining.

That is at the time when he his whole experiences he has brought from the German mining and that is all included in this mine hoisting book. I ask you to do but the other book, like your this mine winding and transport by Walkers. This book is a though it is an old book, give the you can see that how historically the things are there.

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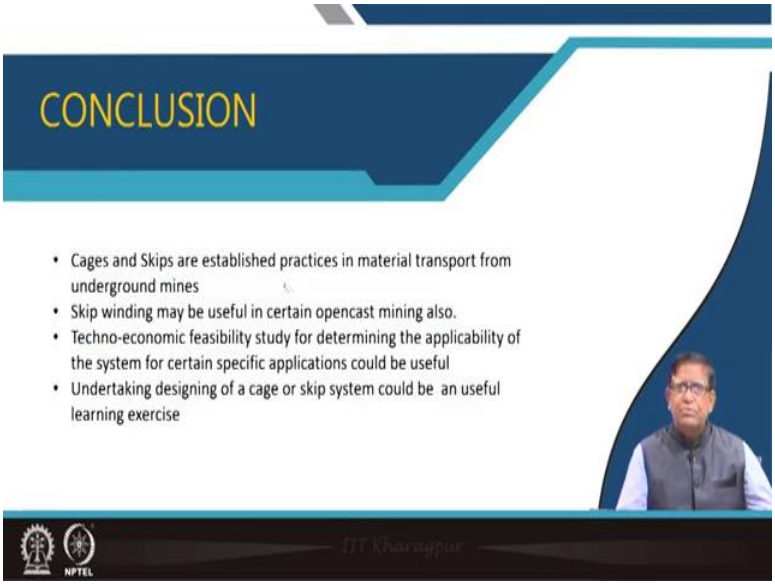

So, I request you please go through it cages and skips are established practices in material transport from underground mines. Skip winding may be useful for in certain open class mines. Also and techno-economic feasibility study for determining the applicability of the system for certain specific applications could be very useful and undertaking designing of a cage or skip system could be an useful learning exercise.

And you can apply what are the mechanical and structural engineering you have learned in your first year and second year can be applied for designing such type of systems. With this I stop here for the discussions on underground mine transport. Thank you very much.