Mining Machinery
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Module - 09
Lecture - 48
Power Requirements for Belt Conveyor

Welcome, students. Today, we will be continuing our discussion with Conveyor Belt. So, we have so far discussed the constructional components of conveyor belt and then what are the design criteria or the design parameters that to be included while selecting a conveyor belt.

And, this whole conveyor belt technology is a very vast subject and there are lot of new applications are emerging and it has got lot of scopes for doing work, both in the operation and maintenance lot of innovative things could be implemented in our existing conveyor belts and also for the future conveyor belt installations new developments are to be there.

Regarding some of the new developments of conveyor belt we will be discussing one more lecture, but today we will be having discussions on Power Requirement for driving a Conveyor Belt which is very very important.

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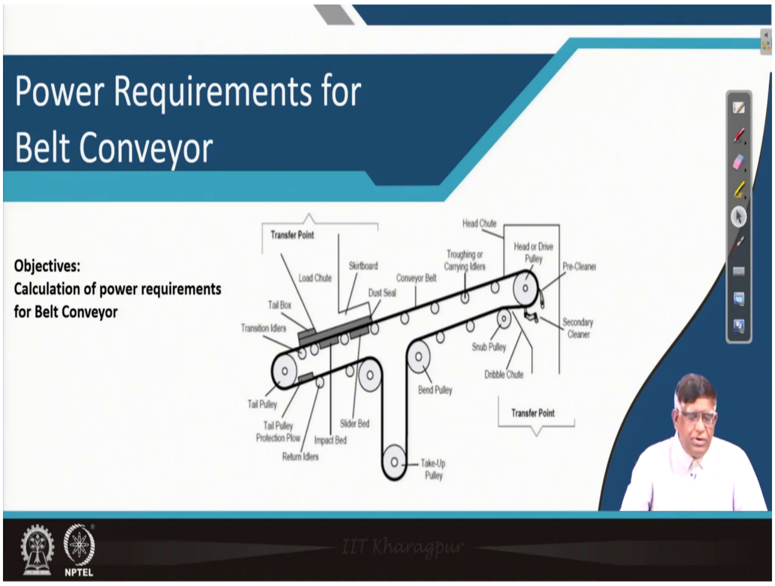

So, let us discuss our objective today is to calculate the power requirement. So, once again you please recapitulate that what you know about the constructional components of a conveyor belt and then you know that you will have to drive this conveyor then the material is to be discharged over here. So, this drive pulley what will be the requirement of motor power to drive this?

So, this exactly the driving of a conveyor belt will be depending on how much total resistances will be coming on this conveyor belt. So, that means, in your all these idlers you can see over here all this rubber is rubber belt or the steel curve belt is laying over this pulley. So, you will have to roll that overcome these frictions at the bend pulleys, at this take up pulleys and then it will have to carry the material; the material load will be coming all along over here.

When it is being loaded, it is just continuously it is spreaded over here and their total weight will be coming over here. So, at this point what will be the tensions in this belt because the basic things is known to be very well known that is if you know the effective tension multiplying by the velocity you can get the power required. So, now, that one how you will determine under different installation conditions that today we will be discussing.

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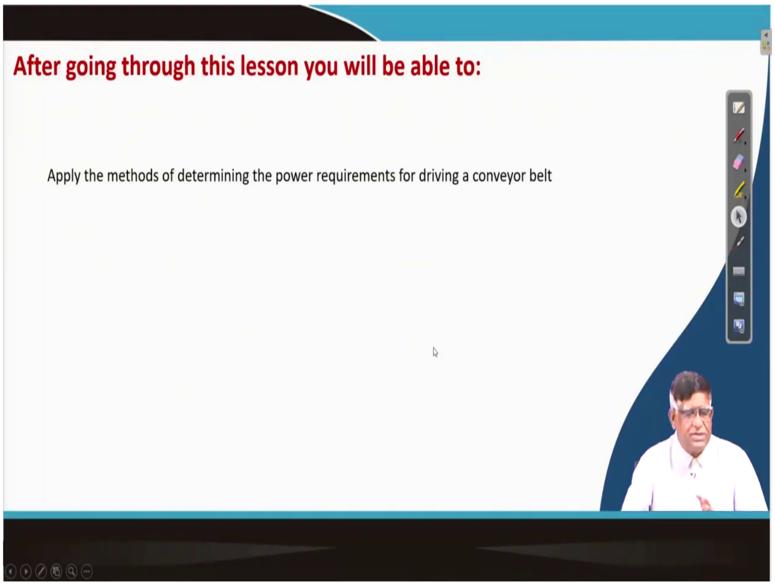

So, our objective is to method of determining the power requirements of driving a conveyor belt, our objective is that.

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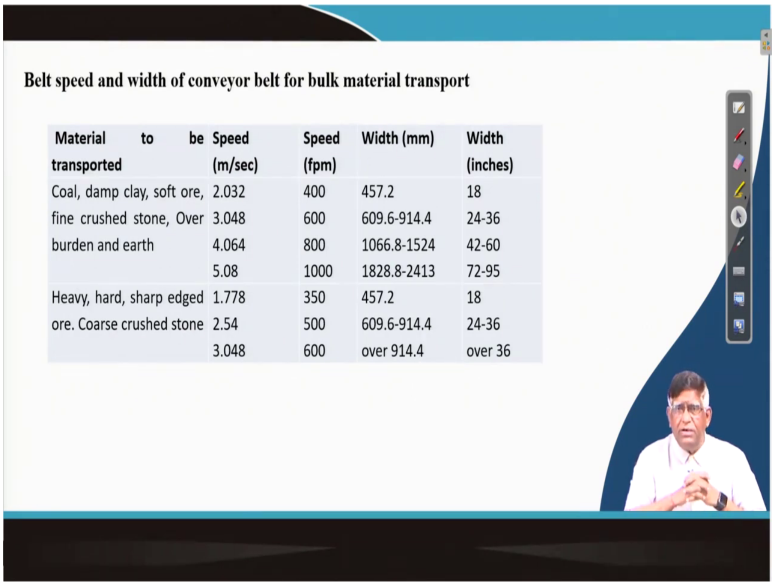

Belt speed and width of conveyor belt for bulk material transport

Material to be transported	Speed (m/sec)	Speed (fpm)	Width (mm)	Width (inches)
Coal, damp clay, soft ore, fine crushed stone, Over burden and earth	2.032	400	457.2	18
	3.048	600	609.6-914.4	24-36
	4.064	800	1066.8-1524	42-60
	5.08	1000	1828.8-2413	72-95
Heavy, hard, sharp edged ore. Coarse crushed stone	1.778	350	457.2	18
	2.54	500	609.6-914.4	24-36
	3.048	600	over 914.4	over 36

Now, one thing here is to be known that as a parameter the power will be depending on exactly that is a how much capacity it is going to carry, that is the tons per hour. That is, how much ton of material per hour it is discharging on that the whole power requirement will be that is obviously understood; the more the work will have to do the more power will be required.

But, thing is that; that capacity it will be depending on two things – one is that your that what is the relationship of the capacity belt width and the velocity. So, it is some of the that is your the speed and width of the belt they are related. That means, you can see here to maintain a particular capacity some of the practical data you can see here that is a heavy, hard or that coarse crushed stone carrying at a speed of 3.048 they can have a belt width more than 914.

You can see here that is your for the overburden being carried at a speed of 5.08 the belt width goes theoretically up to 18.28; that means, that depending on what will be the total capacity or that how much ton it will have to carry per hour that will decide that what will be the belt width and this.

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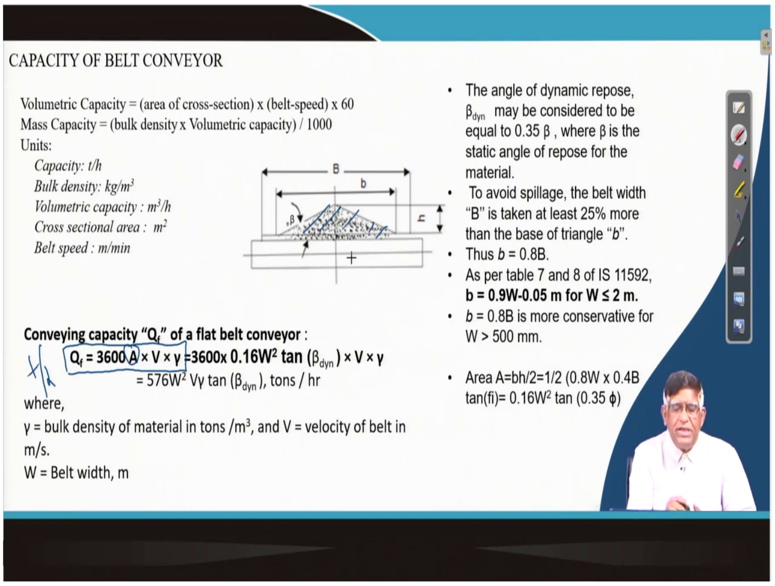

So, this capacity of a belt conveyor that is depending on that cross-sectional area, you are considering here see it is a flat belt. If a flat idler is there on that we are having this B sometimes it is also written as W, that is the width of the belt and this it will have to keep some and we will have to leave it over there. Your whole belt width cannot be filled with the material. So, there will be, so that is a the material is covering a length of say small b here.

Now, when this material is placed on this depending on the bulk material it has got an angle of repose. Now, as I told you other day that is a angle of surcharge or the dynamic angle of repose, that while during the motion this angle of beta will be coming down little less because this material will little settle down or it will fall. So, that is called your dynamic the surcharge.

So, it depends on two type of capacity – one is the volume capacity, another is your mass capacity. Now, these two things we always talk about. Now, the conveying capacity that is it is all you will have to take care of the unit. Depending on the unit you can calculate it out that is what is your, as you can see here the capacity is mainly this 3600 AV gamma.

Gamma if you are giving it in ton per hour, velocity if you are giving in meter per second, area if you are giving in meter square then this 3600 converting the second to your hour that is giving your ton per hour. So, once you are getting this ton per hour as a carrying disc could be; now this A is the area of this cross-sectional area here.

Now, depending on the type of that is your how you are placing this idlers it is a trough or it is a flat this A will vary. So, what is more important here to know is, your conveyor belt, if it is just only a triangular of things you can considering that during this travelling it is taking a dynamic repose angle or surcharge angle can be taken as your this is a 0.35 of the angle of repose.

Now, considering these ones if you bring that area which can come down to be a flatly we can find out this area will be equal to this value. So, this is the way how we can find out that area. Once you know the area as a function of your width of the belt that is once it is width of the belt, then you can find out that width and then there will be relationship at width and the velocity. So, that will be exactly giving you the total capacity of the conveyor belt.

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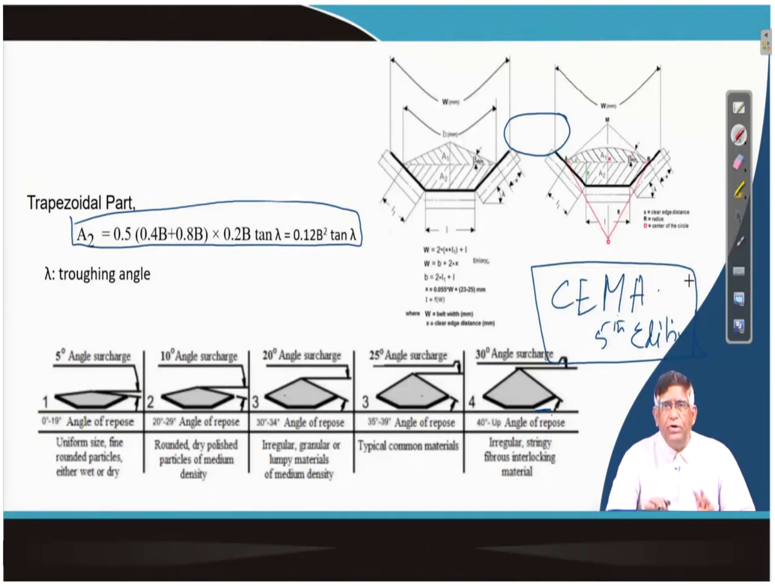

Now, coming to the next things, if it is a trough belt: in case of trough belt exactly the material which will be having two sections say some a trapezoidal and there will be one your, this is a triangular part. Now, this calculation of this area, it can be done there is a some equations are there. You can derive these equations and by that you can find out that this area, rest the same formula you can use it.

Now, one thing is important depending on the type of material and depending on the angle of repose this total area how it will be there will be different. I have always told you that CEMA handbook that is your Conveyor Engineering Manufacturers Associations that is the 5th edition which is now being there, these ones you will have to refer for doing a practical that calculations of this the formula to be used for these purposes because this area is the first part.

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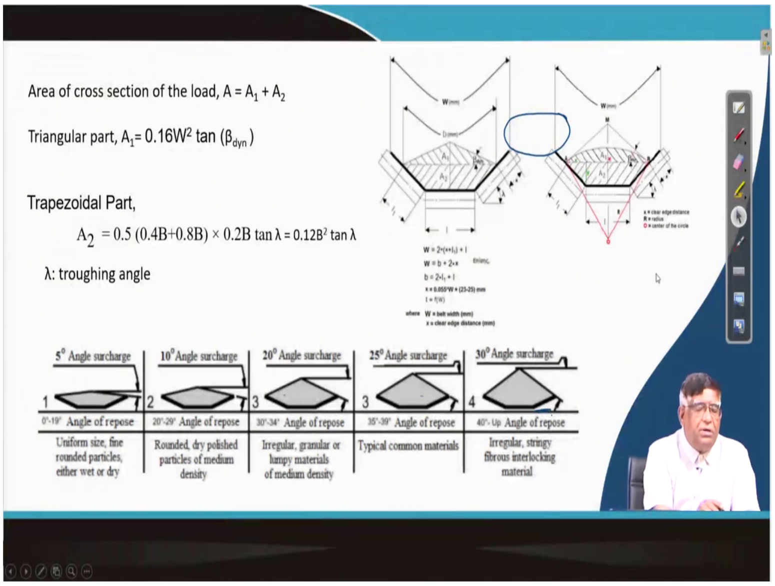

This area sometimes you can calculate.

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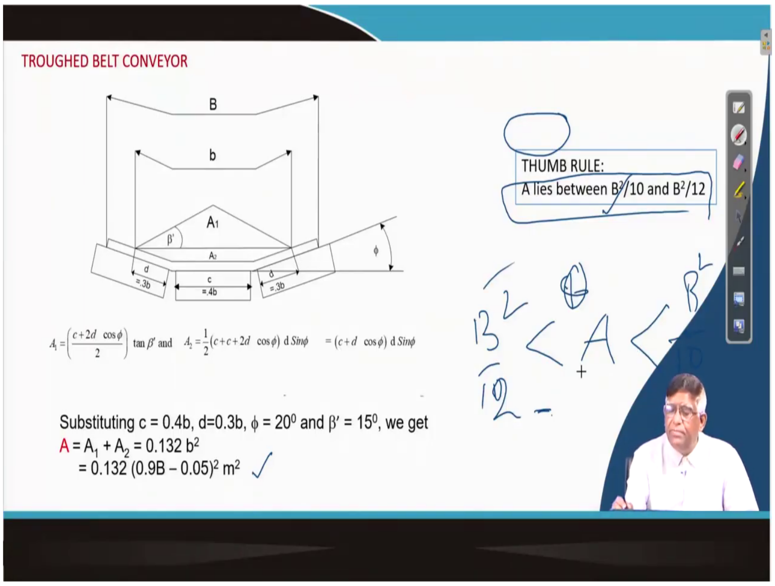

We can derive this area also by you can find out that area of the cross-sections by drawing this diagram and then you can use this dimension geometrically, you can derive this equation and then from that equations you can find out that what is your total area. But, if all these things are not there that if you put it over here this two area, that is your triangular area and the trapezoidal area – these two together you can find out the total area in this form.

Or one thing is there, for doing the initial calculations you can use this thumb rule; that means this cross sectional area is dependent on the width of the belt. That is, if the belt it is if it will be running that is your the your capacity that is your area of cross-sections it will lie that is your it will be B square by 10 to B square by 12 and then it will be B square by 10. So, within that this area will be remaining.

So, this is how a thumb rule has been used for doing the preliminary calculations then you can go for the detailed design calculations.

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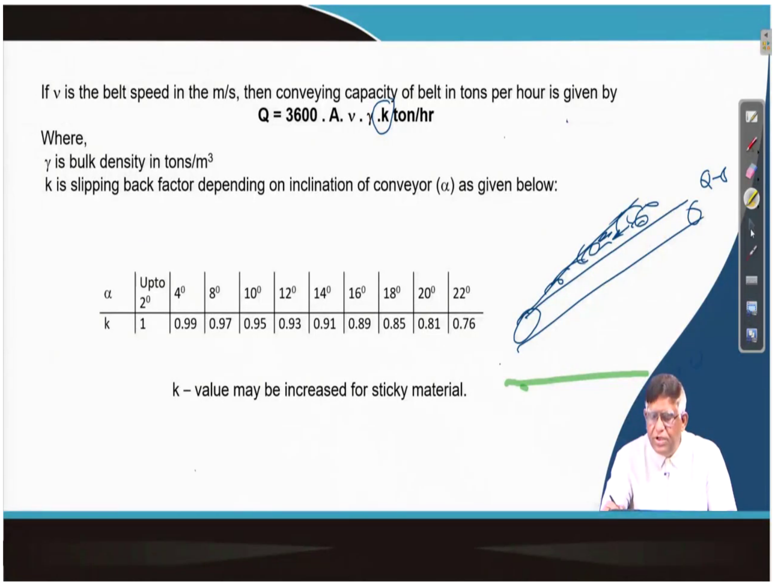

So, this first thing in determining the motor that your driving power you will have to calculate that. So, then your tons per hour can be calculated by applying this formula you know that is Q is equal to A v b that is your area, velocity and density will give. Then there one more factor you can see here this k, it is the slipping back factor.

Sometimes because what happens, while doing this drive is there will be material will be having an adjustment and then while at the discharge point that is there will be some lag that is exactly A v gamma will not be going discharge. So, that factor is important and this factor that is exactly when you are having your inclination of the conveyor belt if it is if it is there.

Now, when that material will be going over here, now because of that weight, material has got a tendency of coming like this. That is why that whatever the quantity would have gone over here it will be having some delta Q less. Now, because of the delta Q less this factor k is used. Now, this k you can see here if it is up to 2 degree if the inclination is up to 2 degree at that time your this k value is 1.

But, as the inclination increases, you will have to use that is your quantity which will be going will be less. So, this part of the things should be clear to you before going for any power calculations. So, I hope you have understood that you will have to what is the meaning of the slipping back factor. The slipping back factor depends on what?

It depends on the angle of inclination of the conveyor belt. If it is more inclined that is your quantity delivered will be reduced more. It can be reduced how much? It can reduce up to 24 percent that is why the minimum value of k is 0.76 at a 22 degree.

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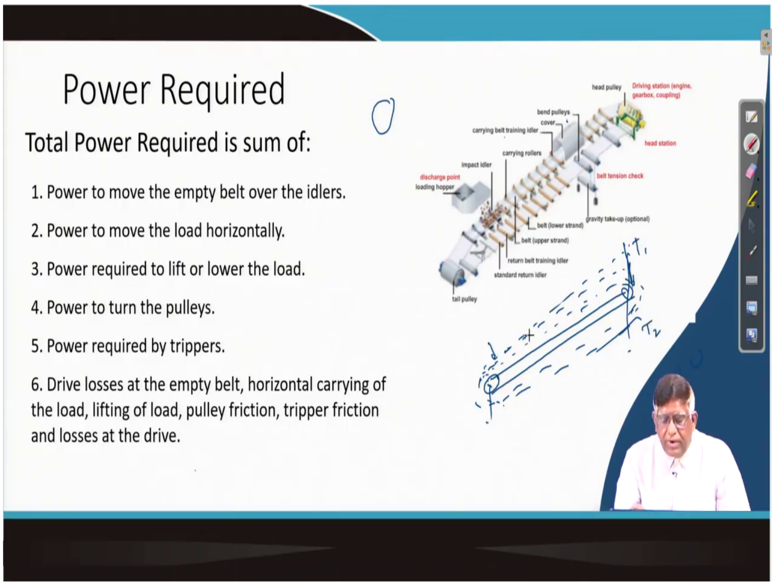

So, once you have learned this next thing what you need to know is your, how will you calculate the power required. Now, power is required for what? To drive it. It is normally it is there stand then you will have to give a motion. Giving a motion means what? Giving a motion means you are overcoming the resistances.

Now, how the resistances will be there? In that installations there will be number of things which will be having a friction. The most of the resistances are having of two types: one is from the gravity weight is there you will have to overcome that weight you will have to do the work to make them material or the made their component to move and the other one is the component will be giving a frictional resistance you will have to overcome this resistance.

So, basically it is very simple. These two type of things, so, the power is a sum of all these overcoming resistances. Where from it will be coming? It is to move the empty belt. Over here that empty belt you think of when that empty belt of length L we have learnt in the previous class how to calculate that length. Now, that will have to overcome over these idlers; the idlers will be giving some frictional resistances. So, it will have to overcome and it will go.

Then power to move the load, that material which is coming over here this is though you may think like that this is exactly a conveyor belt. Now, in that conveyor belt there will be some resistances coming; say for example, if you are having here that is there will be a initial tensions all along here.

This initial tensions will be there and then when your load is coming that load will be going on increasing like this, then your the empty belt it will be having some weight that will be also that weight will be moving all along over here.

So, like that your you will be having that some load will be coming here and some load will be coming here, that way it will be having a tension some over here and another tension here. So, that way you will be determining the total load which will be coming.

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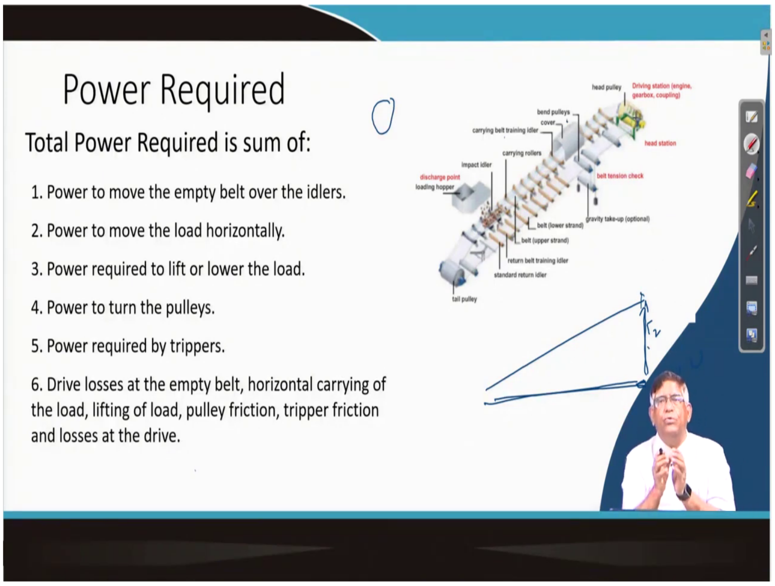

So, that is your material which is moving. It will be going in this direction means, the material will have to move this much horizontally and then this material is going to this much vertically. So, total power required this plus this. So, that is power required to leave the load. These two are the main components from the material part.

Then power to turn the pulleys; at the end this pulley it has got also its own inertia. So, you will have to make the pulley to move, for that there will be some power required. And, then there will be some tripper that is in between you may have to have the side discharge loading and all that thing in that case that whatever the resistances it will be given by the tripper, that will also coming with that.

Along with that there will be that your how you are horizontally carrying of the load, lifting the load, pulley friction, tripper friction all these frictions will have to be taken into consideration.

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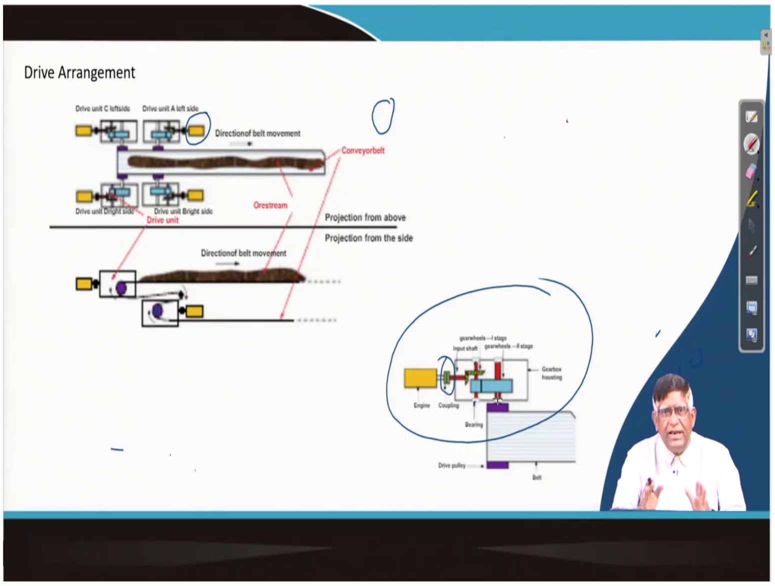

So, basically once you know that these are the load what you will have to do, how will you put the drive? These are the things while doing one is you will have to know how much is the power to be given; that means, the motor which will be driving this motors power will have to be known.

Now, second questions will be coming where you will locate the motor? That is normally it is there wherever the this is your the t 1 and t 2 this their differences is more that will be the best location, but that location depending on your site conditions, but we can have a single drive or dual drive; that means, you can have at one end or you can have at both end or intermediate drive can be given.

Now, if you see a top view of a conveyor belt you can see this is the conveyor belt. Here in that conveyor belt we are having exactly two pulleys the drums are here which are driven by you can have single or it can have double or you can have four motors depending on that what is the total load and how much capacity is required you can give over here.

So, this is exactly that means, the conveyor belt is coming like this, it is coming and then it is going over here and then it is going on another pulley and it is going. So, that means, you are having this driving drum and this is your driving drum 2 and pulleys are driven over here.

Alternatively, there could be only at one end. You are having a electric motor, from the electric motor you can run a gearbox, from the gearbox shaft you are giving a drive to this gear and it is giving and then pulley is rotated and conveyor belt is running. So, this is a single arrangement over here. So, in that what is exactly here? We are having a drive pulley.

Now, while making these arrangements to drive these components need to be very well decided that with the your main motor that is prime mover it will have to be coupled with the gearbox. Now, that what type of coupling you will be selecting that will also be very important, and then your what type of gearbox you will be using that will be important and these gearbox, their shaft which will have to be mounted on some bearing, what type of bearing it will be selected.

Then this will be again given to this gearbox will be connected to this shaft, that is how will you be using a spline or how that is exactly will be connected to this gearbox that is where you are having another coupling that will be also deciding factor. So, basically while designing the whole thing we go to that, intricacies of each and every point of it.

So, at this stage you now know that you will you have to calculate the motor power and then you will have to locate them accordingly. And now you should have a very clear in your mind that how the things looks like.

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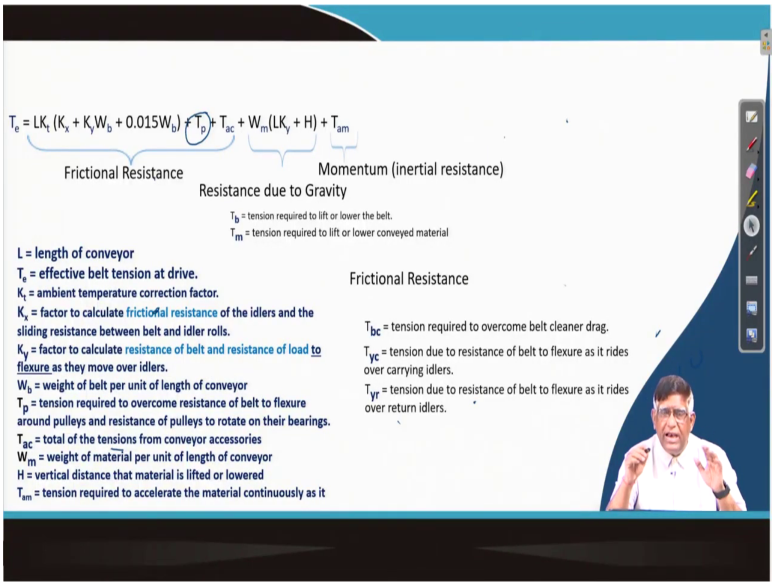

So, now if we see the CEMA handbook you will find the total power that is exactly total resistances or the total force which will have to overcome that is your effective tension, which will be exactly there on the conveyor belt with which it will be moving, that tension is exactly the or the resistances, total resistances is coming from the frictional resistance, from the resistance due to gravity and from the momentum of the inertial resistance. So, these three components are to be overcome.

Now, when we talk about this frictional resistance, it is coming because of the length of the conveyor and then your total effective belt tensions at the drive that is how much exactly the belt tension is coming will be depending on this length and they have got an impact of the ambient temperature that is multiplied by this factor.

Then, there are frictional resistances of the idlers and the sliding resistances between the belt and the idler rolls that is coming the factor K x. K y is a factor to calculate the resistances of the belt and resistances to the load due to the flexure as they move on the rollers and then weight of the belt that is per unit length.

So, now that belt is having exactly on the idlers it will be giving its own weight and when the material will be coming, from the material also it will be giving per unit weight that material weight will be coming. So, two things are coming. You can see that due to the gravity we are getting this material weight coming over here and this is your weight of the belt empty belt it is coming over there.

And, then there is a tension required to overcome the resistances of belt to flexure around the pulleys there is another resistances. So, and the total tension from the conveyor belt accessories there are so many idlers and other things there which will be also giving. So, in CEMA handbook, they calculate the resistances each of the factors there is a norms by which they are calculated and do it.

So, now the frictional resistances are basically the tension required to overcome the belt cleaner drag because the belt cleaner will be there. There also will be giving a drag, then tension due to resistances of the belt to flexure on the while carrying idlers will be separate, then on the return idler will be separate. So, all this intricate resistances are taken into considerations when you are going to real life designing of a system.

Now, coming to this gravity resistances, for the that how much material you are going to lift up that will be mainly giving your gravity resistances.

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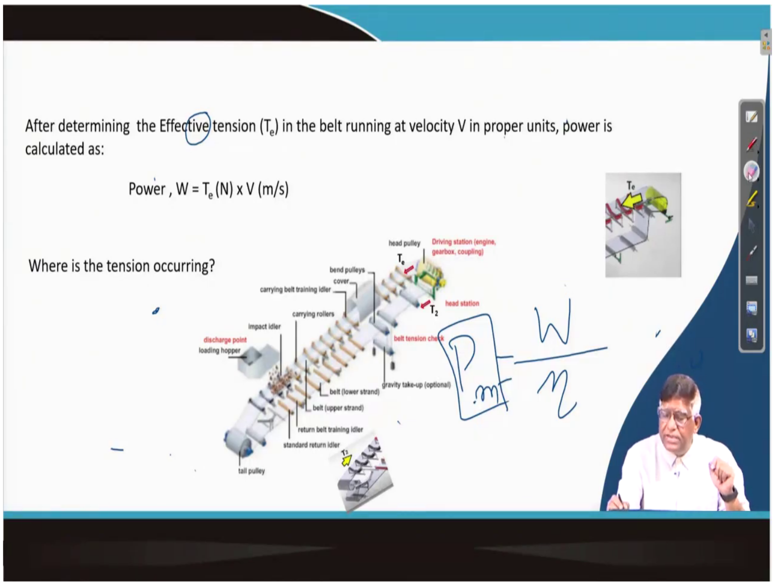

So, once you calculate out the resistances that effective tension in Newton and then you know at what velocity you will have to run because the velocity you have determined from the required capacity, from there the velocity has come. Now, you can find out that what will be the power requirement that is the power.

Now, if this power if you are divide by that efficiency of your motor; that means, if this power you are whatever the W you are getting if this W you divided by the efficiency that will be giving you the power of the motor. So, that is the basic principle. Now, you can see here few things are very important.

Now, this that when you are driving this is exactly at this end drum, there will be a effective tensions which will be coming along this. You are overcoming this and then only you will be able to rotate it. Resistances are in this direction, so, you will be rotating the motor so that the material will be going like this.

Now, when will be going and that is why this is your slack side there will be another tensions coming. Now, this one these tensions will be at this. This is here it is call your slip side, it is call your slack side. In that the same tensions T 2 will be coming over here and then this exactly how you will have to take into considerations for calculating the power.

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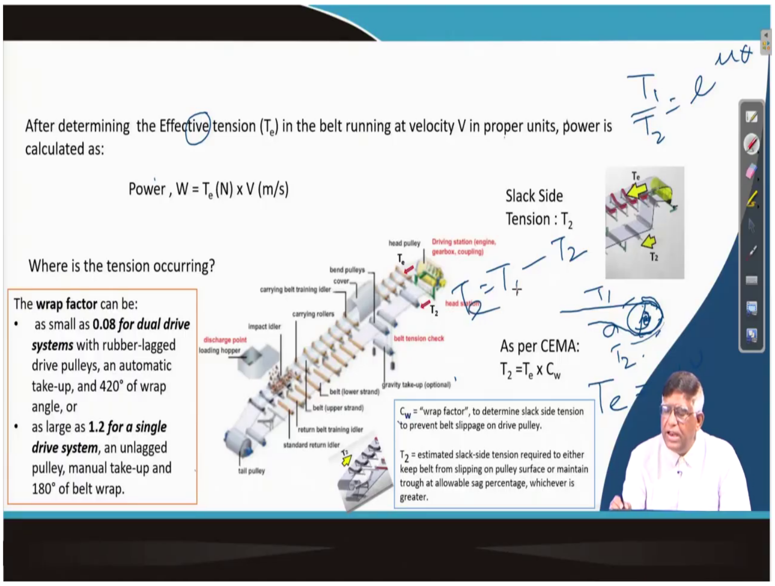

Now, this is in your slack side you are having this T and T 2 and then as CEMA they take that T 2 is equal to T into C w that is called your wrap factor. Now, this traditionally we have taken the T 2 and T 1 ratio you know from the Euler's equations that is your normally they have taken in a CEMA handbook that is your wrap factor it is taken into account and then with that they have given. But, in other cases we calculate that T 1 by T 2 is equal to e to the power mu theta.

So, that means, whenever it will be going over here normally you will be giving a snap pulley to increase this angle of wrap, that angle of wrap is this theta. So, that if it is your T 1 if your T 2 that T 1 by T 2 will be equal to e to the power mu is the coefficient of friction between this rubber belt and this your pulley. So, this exactly give you for calculating and T effective tension is nothing but T e by equal to that is your T 1 minus T 2 is your effective tension.

Now, these ones once you find it out, then you can calculate out this power.

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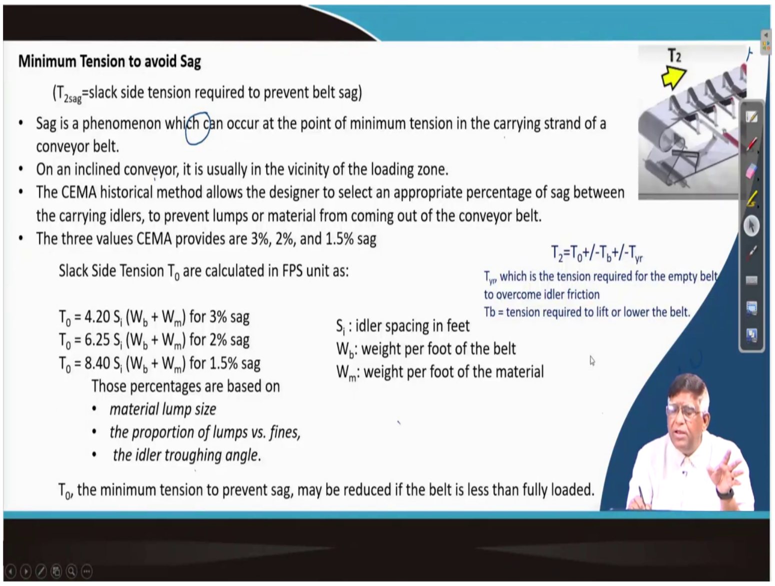

So, now that is your if you find out this is your maximum tension we will have to avoid the sag. There are slack side tensions that T 0 are calculated by these equations which is given, they take it. Sag means, exactly there is a between this when we are giving a conveyor belt over here it will sag like this. So, that means, there could be a sag.

So, similarly at your when you are taking a belt like this, so, that there will be some sag over here. Considering those things they calculate out that what should be the this tensions in the belt due to this sagging. So, once this is determined then you can go for doing some that is your idler spacing also need to be calculated out.

That exactly the handbook gives those also for a particular drive what should be the distance between two conveyor that is on support roller because if the sag is more, then there will be a different type of your force requirement also will be changing over there.

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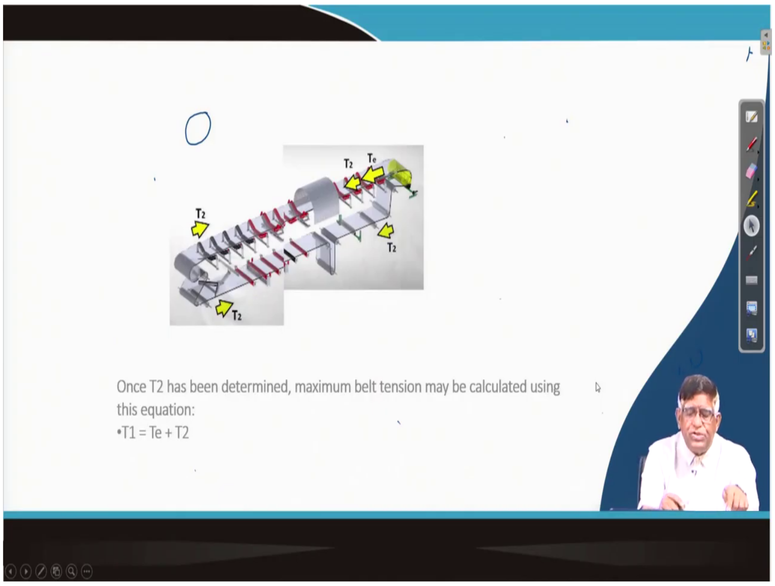

So, once you find out this T 2 that is your slack side tensions, then you are able to get; that means, your the total your effective tensions that slack side tensions that will get distributed over there.

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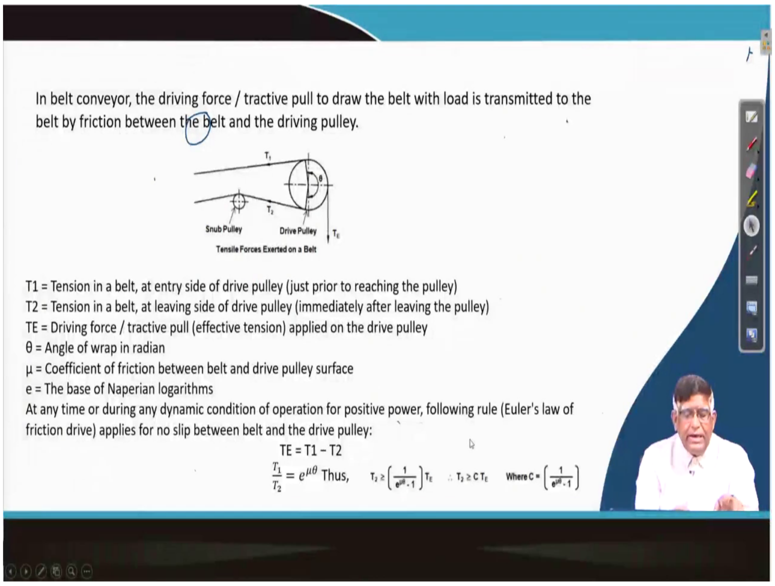

And, from here you can find out this what I was telling you about that T 1 by T 2 is equal to e to the power mu theta, it can it will be being your driving or the power calculating equations. So, you can find out T 2 is equal to this this particular factor which will be giving you the measurement of this tension.

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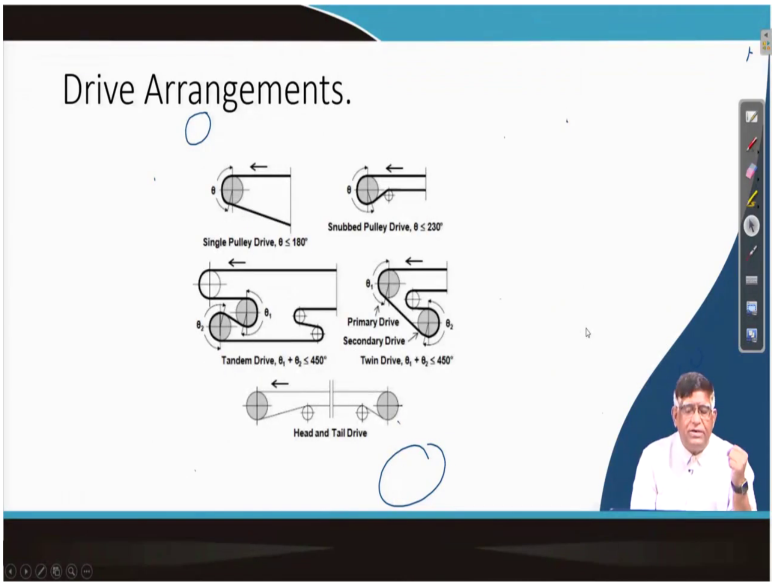

So, Once you have got the tensions, your drive arrangements which could be it could be your at one pulley you can give the drive at two pulleys.

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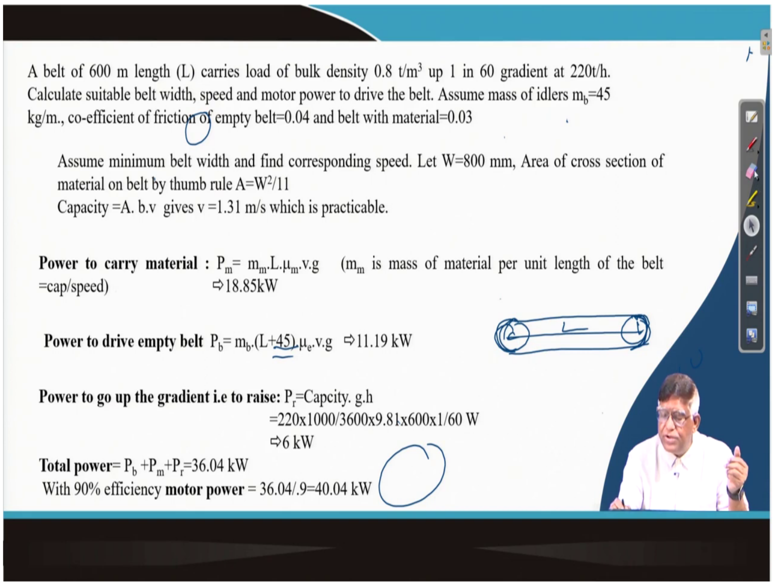

And, then you can mainly what we knew about that there will be power of three components are very important. One is your power to carry the material, that is your that what is the mass of the material per unit length that from the your required capacity and the length distance and the velocity you can calculate that how much exactly the coal or iron ore is coming every meter of the conveyor belt, you can calculate it out. Then the length of the conveyor and then you can multiply this.

Now, to drive the empty belt, what is there? Your this length is given one unit this 45 we are taking as a thumb rule because when the conveyor belt is running over here it is taking a distant. So, this L we are taking over here and then your this part we are adding a another 45 is adding because of the frictions which will be coming due to this.

And, then rest is that your empty belt on the conveyor belt when it runs that what is the coefficient of frictions, when the materials it will be having a coefficient of frictions with the belt. Then for the raising you know that is your the capacity whatever your tons per hour it is going into g into h will be giving your how much it is to be raised. So, this three power if you sum up that will be giving in kilowatt your total power.

Now, I think if you have learned this, you can now calculate out a some exercise to do this. Say for example, a belt of 600 meter length carries load of bulk density 0.8 ton per meter cube up to in a 1 in 60 gradient 220 ton per hour. Calculate the suitable belt width, speed up the motor power to drive the belt.

Assume mass idler is your m b that is mass per unit length is 45 kg per meter which if it is not given sometimes if your ton per hour is given and the velocity is given, from there you can find it out then coefficient of friction of the empty belt is given. So, from here you can take that is your A is not given you can use this formula for finding out and then capacity you can get it from here and the from this particular formula, you can find out what is the velocity.

So, once you know that velocity put the values then you can find it out. So, you will have to do such type of exercise for doing it over here.

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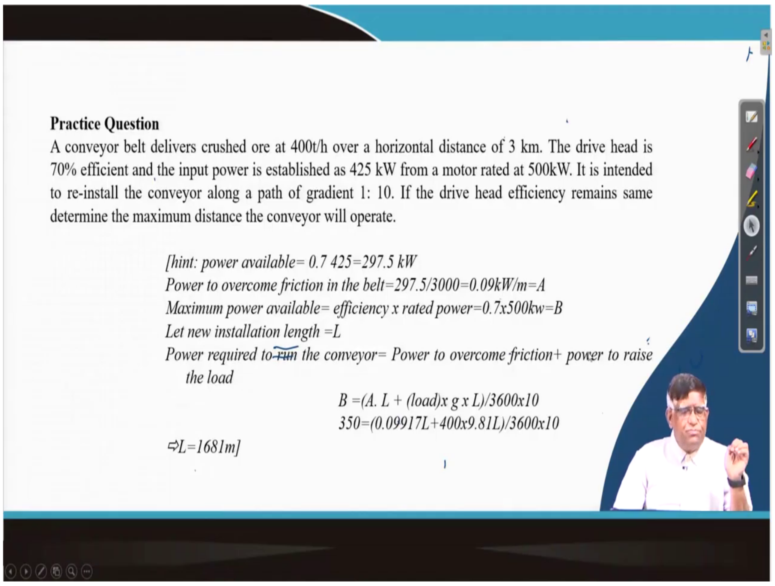

So, one practice questions please note down. A conveyor belt delivers crushed ore at 400 ton per hour over a horizontal distance of 3 kilometer. The drive head is 70 percent that 70 percent efficient the and the input power is established as 425 kilowatt from a motor rated 500 kilowatt, right. So, it is intended to reinstall the conveyor along a path of gradient 1 is to 10. If the drive head efficiency remains same determine the maximum distance that conveyor will operate.

Same problem, only that you are asking to do in a different manner. So, what you can do? What is the power available, you need to find out that is your 70 percent is the efficiency given. So, this will be giving you your 425 kilowatt motor. So, your available power is given over here.

Then what you can do? To power to overcome the friction in the belt that you can determine that is your you have after finding it out that is your you can find out the what is the maximum power available from the efficiency and the rated power, then you can calculate out that is what will be a installation length keeping it L you apply this equations, from there you will be able to find out what is a L.

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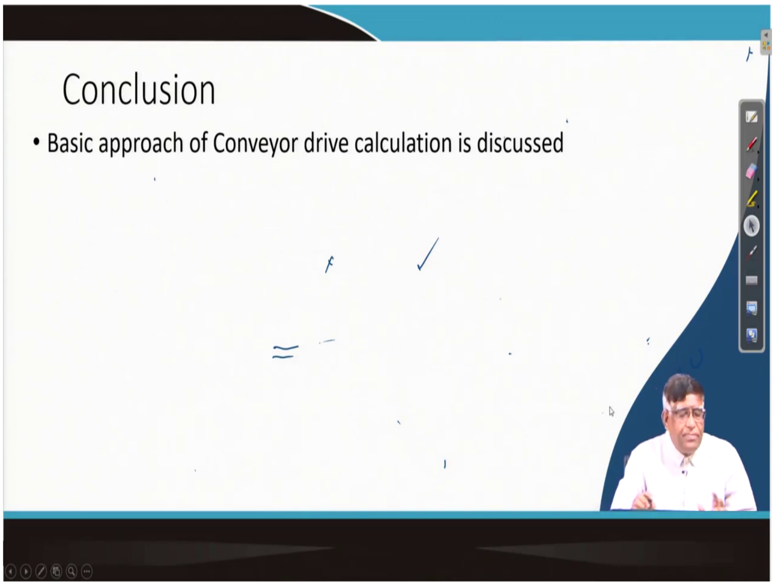

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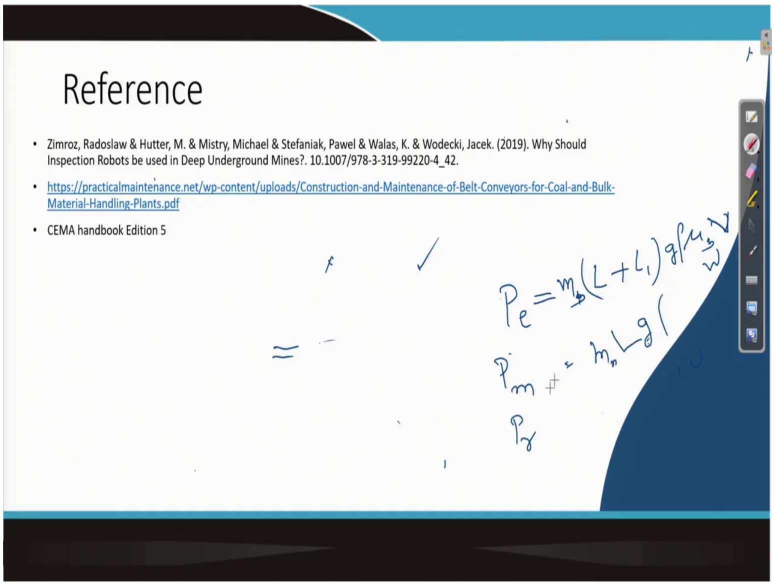

So, that means, the that there could be number of this type of exercise to basically what you need to learn is that is your the basic approach for conveyor belt drive is you will have to determine what is the power required for your power required for empty belt, power required for material, power required for your how much power required for your raising.

And, that power required for empty belt will be depending on your length and then also some additional length you give for the wrapping over here. And then what is the weight of this belt per unit meter? If you multiply this will be giving you the weight, if it is given in mass you will be multiplying by g, if it is given in kg you are multiply by z to convert into your unit.

Then what is that your coefficient of friction of this belt over there, then you will be multiplying by the velocity, this will be giving you the that is your when you multiply this mass by the density and then to multiply with the velocity, it will be giving you the power in watt.

Similarly, for material you will have to get this material how much material is coming per unit length, then how much length it is giving, then it is what is this density and then we can find out it. Like that your that equations which is derived and given in the this lectures will be allowing you to calculate out the total power and once you know these equations, you can find out how exactly the your a conveyor belt drive can be calculated.

So, I hope you have understood that what is the conveyor drive and for driving the conveyor belt you will have to calculate its capacity, you will have to calculate its relationship with its speed and length and then the motor power then lot of other installations and area constraints will have to be taken into considerations.

Thank you very much.