Mining Machinery
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Module - 02
Lecture - 04
Belt Drives, Chain Drives

Welcome back to our discussions on Mining Machinery. We have been talking about mechanical power transmissions.

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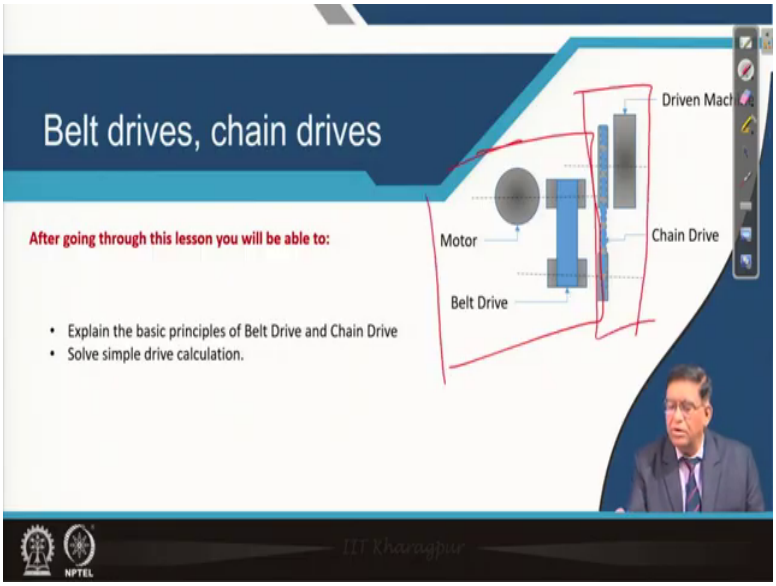

And, in this today you will be knowing about two types of drives that is belt drive and chain drive. So, after this class you will be able to explain the basic principles of belt drive and solve some numericals based on this applications of belt drive and chain drive.

As you can see here that we are having this two types of drive systems here, this portion is showing your what is our belt drive and here you can see this your this we are having our chain drive. In this chain drive and belt drive, basic difference is here from the electric motor you are transferring the power to a belt and from there you are going to a whatever the drive systems you are having.

You may have from this belt that from the electric motor the power has been transmitted to this belt and from this belt it is going to this your chain and from that chain to the machine which is being driven.

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So, this basically what we do is our main purpose of this system is a to drive. As you can see here in this some of the applications simple you might have seen your rice mill near your town where there is a electric motor is giving and the power is being driven by belt drive over

here. There also you can see a conveyor belt is being used to drive that belt. There is a pulley on that exactly the electric motor, there it is connected with a belt and this just like a your a belt is running over here.

Similarly, that number of drives number of machines or number of shaft can be driven by when your this one that shaft which is connected to electric motor has got number of belt and which is going to drive number of shafts. So, these are the some of the things you can see.

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Similarly, the chain drive in place of blade that your belt you are having the chains. In mining industry there are number of places where you can see this chain drive that the chain is used for conveying purposes. You can see that here that electric motor is giving the power through your gearbox to the sprockets of the chain in chain conveyors.

In some machines like continuous miner there also once this drum is cutting the material and then that will be falling on through this your collecting the material and there is a chain conveyor chain drive is there which will be giving it to this. Similarly, there is a bucket chain excavator that whole boom there are number of buckets are connected to the chain and the chain drives this bucket for collecting the material and that that is a big machines are being used by using this drive systems.

But, basically you know you all have seen your bicycle has also got a chain drive. A chain drive is nothing, but it has got a chain and then two sprockets by which exactly you drive this there is just like you say here as a pinion and then the gear. In case of your gears here also you are having one small sprockets one bigger sprockets and then we are getting some velocity ratio of these stripes.

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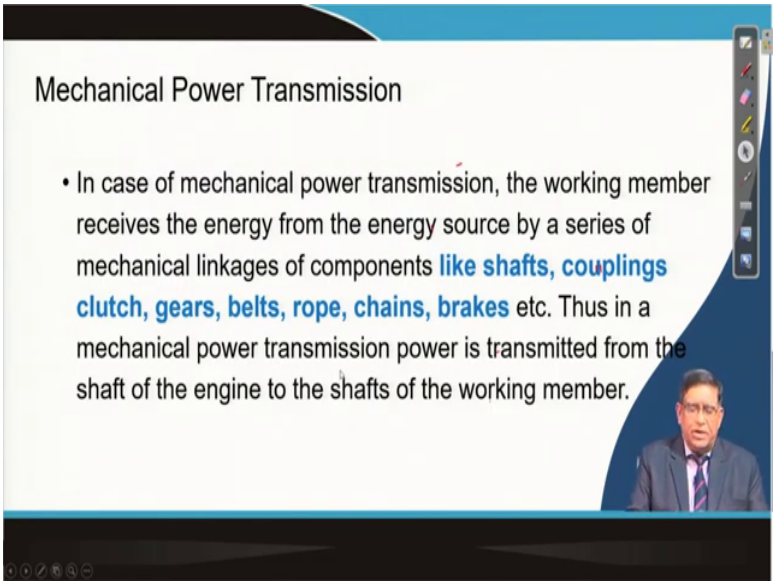

So, similarly when we tell in a general you know that mechanical power transmissions it is taking place by using number of components. In our last class, we told about that this shaft, couplings, clutch, gears they are used; now, these ropes are also used over here.

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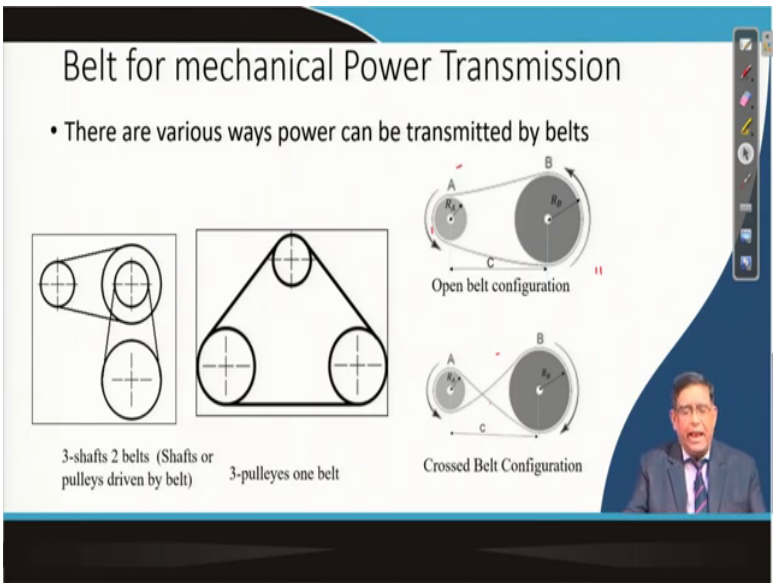

So, now, in this system exactly that your belt power, belt for mechanical power transmission systems can be arranged in a different way depending on the purpose, depending on this type of things you might have seen some of the fan belt in case of your if you have opened up in your cars hood or you can see that is from the engine how the fan is driven by a belt drive.

And, the there are there could be your two belts and three shafts are there connected together. Sometimes by one belt itself three shafts are three pulleys are connected together. Now, these belts can be given as an open belt configuration or crossed belt configuration. Now,

depending on the use and then how the mechanical design goes this type of things you can see in different machines.

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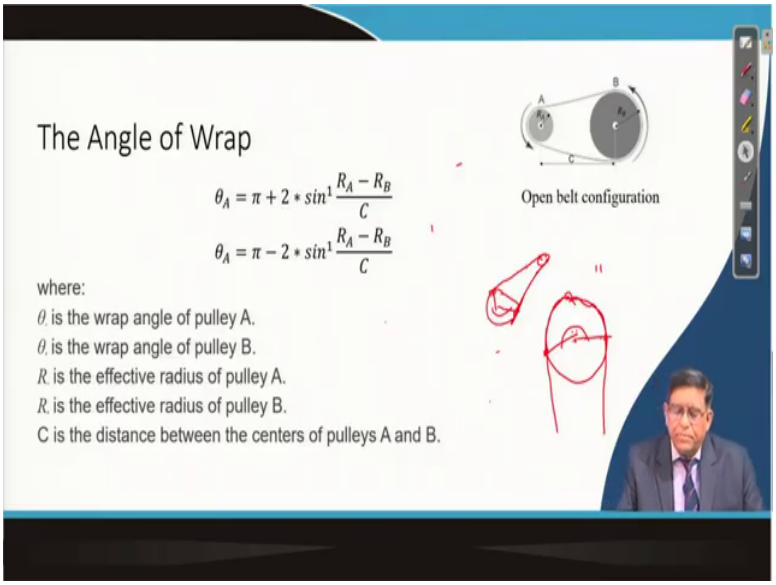

Now, there is one thing is very important here you need to know about the angle of wrap. So, basically when we are having a belt drive that is your belt is running over there so, this is your when a belt is going like this it is connecting with the pulley and then there is a center it is suspending an angle. This angle is called your angle of wrap.

And, this angle of wrap can be that is calculated at or it depends on this in type of in this type of your belt drive system there is for two pulleys are there; here pulley and this is a bigger pulley. And, in that pulley A and pulley B their angle of wraps it is can be connect calculated by this equations you can see here.

The difference is that is your here it is a little less here this angle of wrap has increased because when it is going from the bigger one to a smaller one exactly while it is going it is leaving at a this area. So, that is why this angle get increased, but here it get decreased.

That is why these equations you can remember that is the differences of the radius and then depending on that what distance of separation between these two that affects the angle of wrap. And, this angle of wrap has got a lot of importance regarding that how the tensions will be coming on into the different belt.

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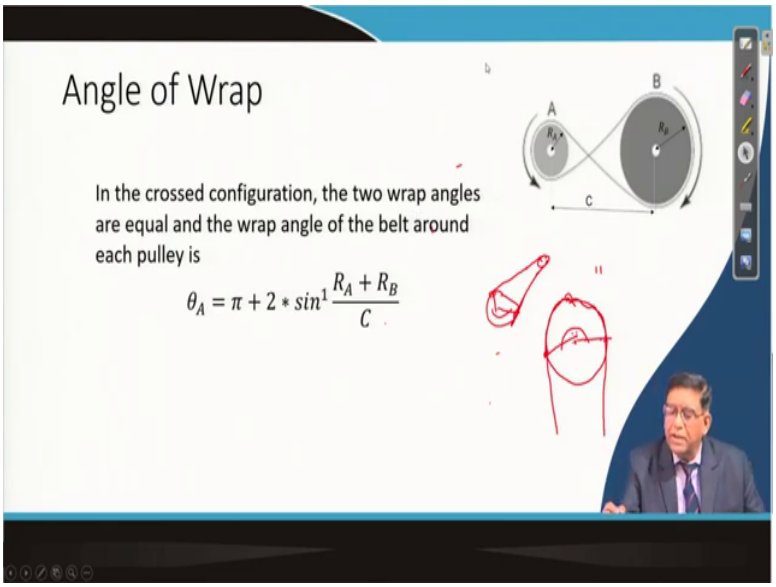

So, one thing you need to know here that if we see here this angle of wrap can be for your cross belt and for your this both the configurations it is the same that is your in case of this configurations your cross belt configurations this is calculated by means of this.

So, here exactly in your smaller that your pulley also you are increasing the angle of wrap by giving this method. So, in this way your angle of wrap can be changed in case of your cross belt.

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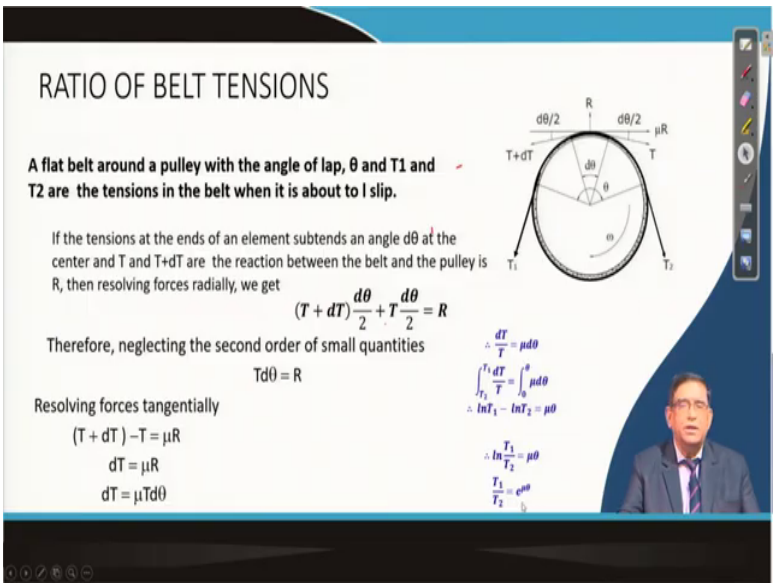

Now, you can see over here, this how that belt tensions are coming. So, that means, when this belt is going around this pulley you are having that both the sides there is a tensions as this shown here T 1 and T 2. Now, you know that whenever there will be another pulley like that when both of them are connected together by the belt the belt must be properly taut tensed.

Otherwise what will happen this the power transmission will not take place because here the power transmission is by the friction over here. To get the power transmissions this will have to be proper tension will have to be maintained.

Now, let us see here there is a there should not be any slip that is a power transmission. For that, no slip what is the conditions required? If you see here that is your if the tensions at the ends of the element subtends an angle your d theta, then this tensions can be resolved into two components that is your T and then T plus dT.

So, that means, from here it is coming over here slightly that it is getting tension increased and this part that is your if you see that resolve them into the force this is the reactions normal reactions. Then what it will be there? The relationship you can write down that T plus dT d theta by d 2 this and this together that all this your you are resolving them into this force.

So, these gives that if you now d theta dT by 2 this will be a very small infinitesimally small. That is why, your final thing will be d theta by dT into d theta equal to R you can do this things. Then if you resolve it tangentially and what are those forces? Then this T plus dT minus this T this is in the original directions it will be as a mu R.

So, that ultimately what you are getting? You are getting this your that increase in that dT by this T equal to mu d theta. Now, if we integrate it and then between this two limits that is if we say that this tension has got exactly it is from T 1 to T 2, then these integrations is giving you your log of T 1 by T 2; that means, you are getting T 1 by T 2 is equal to e to the power mu theta.

This is exactly called Euler's equation and this equation is a very fundamental in all your belt drive related calculations. So, this tension ratio as you have seen this derivations that if it is your tight side and this is your slack side that T 1 by T 2 is equal to T 2 into e to the power mu theta so that this part.

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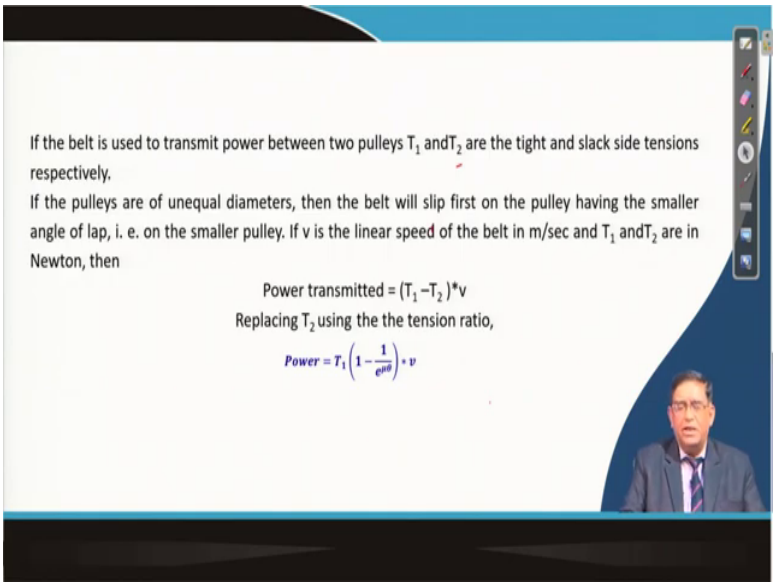

If the belt is to used to transmit power between two pulleys T 1 and T 2 and that tight and slack side tensions are given then you can calculate. Now, if they how much power will be transmitted then. The power transmission is depending on that effective tension; that means, if your this T 1 is your tight side and T 2 is your slack side tensions, their difference is the effective tension by which it will get pulled in this directions.

Now, that effective tension into velocity that will be giving that much power will be transmitted. So, this once as you have got from the T 1 by T 2 is equal to e to the power mu theta from that equations if you replace this T 2 here, you are getting the power is equal to this particular equations.

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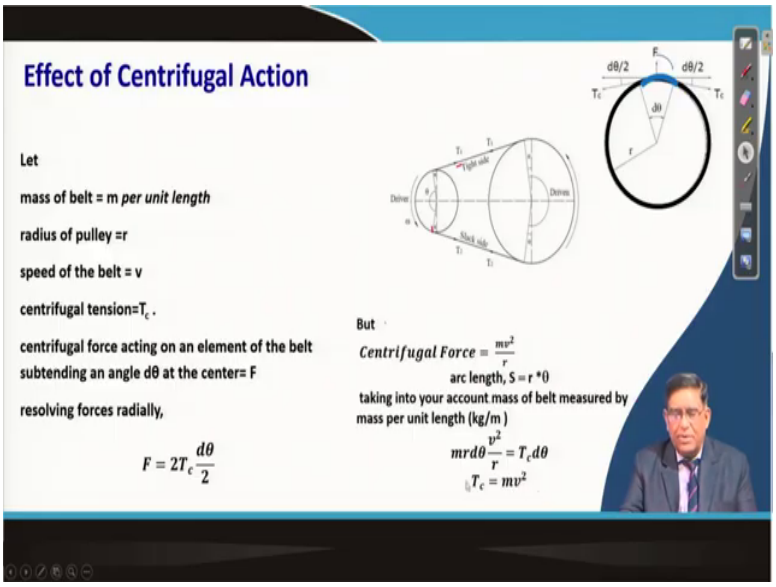

So, now the second question comes over here that there will be a centrifugal actions because when it will be rotating you know that there will be a centrifugal actions part of it.

Now, this will be depending on what is the mass per unit length of this belt, that is, your if you are taking this radius of that pulley is r and then the speed at which this belt is moving is at v and then let us take this centrifugal tension is T c, then you can calculate that is exactly what will be the your that force which is coming over here F, this force can be calculated as this your twice this your this T c part that is your centrifugal actions into that d theta by 2. This result; we can get it from the force resolution resolutions.

Then our centrifugal force which is we know all of it is mv square by r. Now, here this arc length which is there that is given by r into theta. So, from here if you just do a little bit of calculations you can find out that your the centrifugal force is nothing, but mv square.

This is also a very common equations. You might have done it in your earlier classes. But, this T 1 by T 2 is equal to e to the power mu theta and this centrifugal force is that is your coming centrifugal actions given as a tension T c is equal to mv square.

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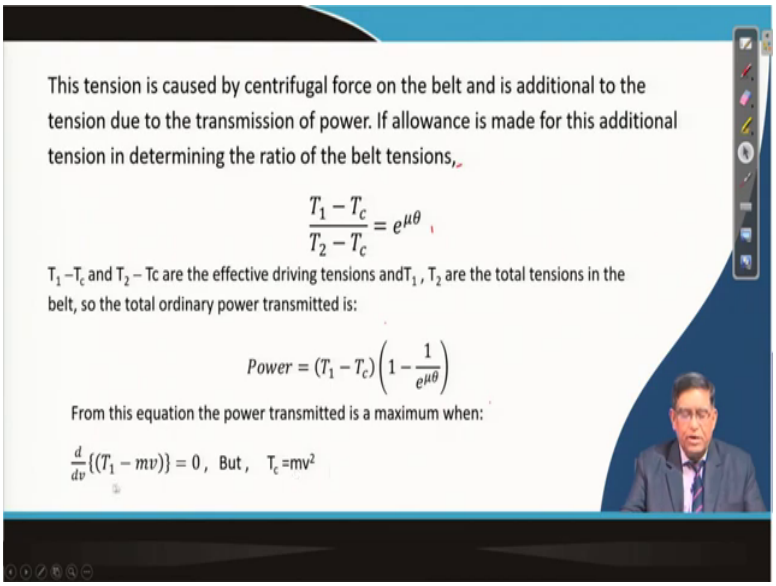

These two then this tension is caused by the centrifugal force on the belt and is additional to the tension due to the transmission of power because there was a because of the tensions in the belt we had got this T 1 by T 2. So, this coming into the boats that is why it is coming that if you consider the centrifugal action, the equations Euler equations will be changed to T 1

minus T c by T 2 minus T c that. What is this T c? T c is nothing, but that mv square by mv square r.

So, this T 1 minus T c and T 2 minus T c here this is the effective driving tensions and T 1 and T 2 are the total tensions, it is taken like that. So, that power required; that means, your total effective tensions will be coming the product of these two. So, this is the way how you can calculate out that power transmitted can be maximum when your the this if you resolve it their derivative will have to be 0. So, as our from their m value, we can put it from this equation that is your centrifugal tension is equal to mv square.

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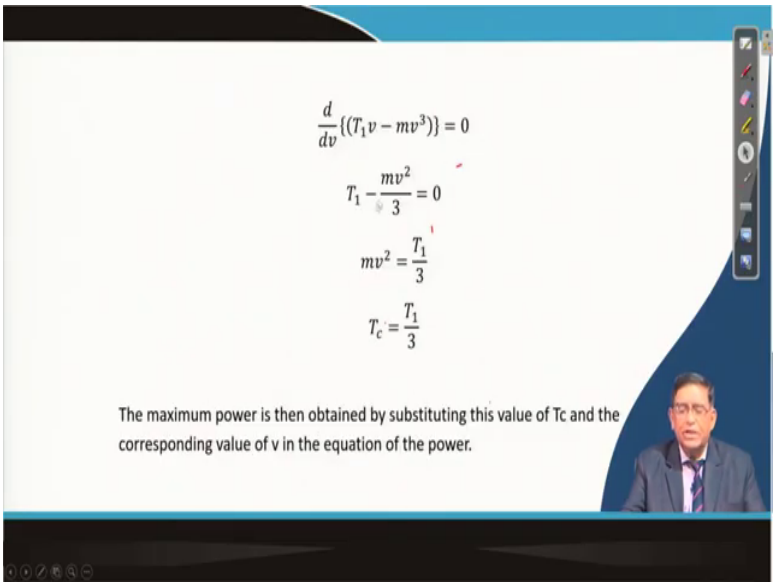

So, if you put that value over here then you can get this the it will be mv cube because of the value of the T c has been put over here. So, then what it is coming? This is your if you take

the derivative of it ultimately the centrifugal tension is coming that maximum tensions into one third of it. So, this is the way how you can calculate it out.

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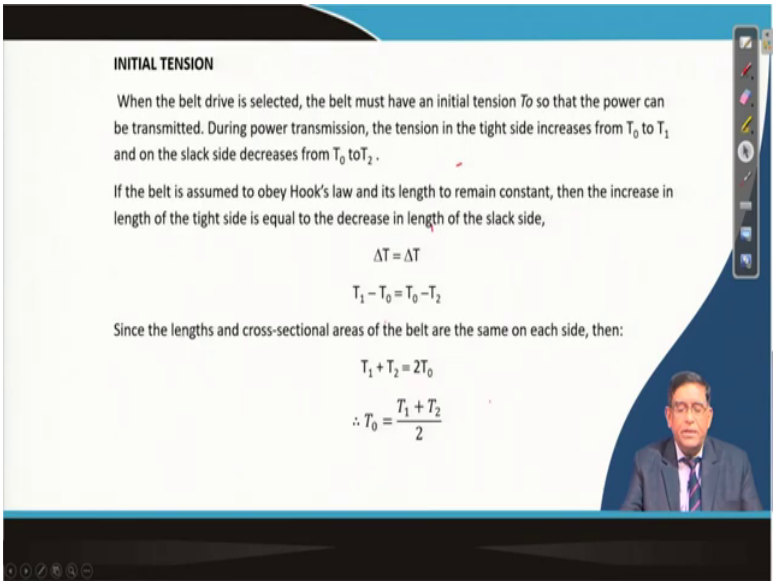

Now, how do you calculate this initial tension; initial tension that is when the belt drive is selected the belt must have an initial tension because if you do not have a initial tension then the you cannot drive it will be just slipping. So, now, this is because if you see that drawing where we have seen here your that both sides your this initial diagram you can see here that delta T.

This delta T part are remaining same if you consider that from the slack side and the tight side from the initial tension differences. Then from here we can find out that initial tension is nothing, but that will have to be the sum total of these two. So, that means, whenever we

make a tensioning arrangement in any belt or any belt drive that will be this much tensioning will have to be given initially.

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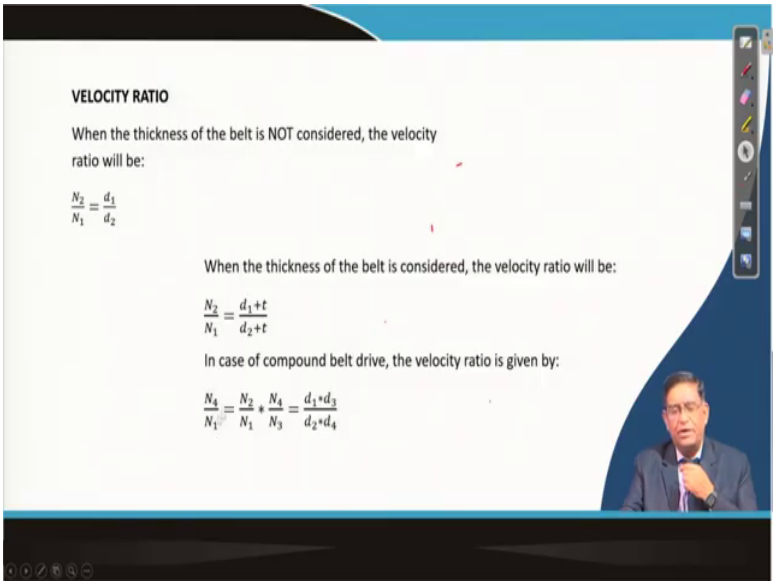

So, the velocity ratio is the ratio of the say if your the driven pulley and the driving pulley their velocity is inversely proportional to their radiuses. This is just like in the gear also you had this, but if there is a you consider the thickness of the belt then this ratio will be considering the that T is the thickness of the belt.

So, if you are having a compound belt drive number of pulleys or number of drives are there then they will be just going on multiplying it over there. So, there is say for four pulleys are there – the ratio of the final drive one and that your initial drive one that will be given by the multiply of it. That simple calculations are there.

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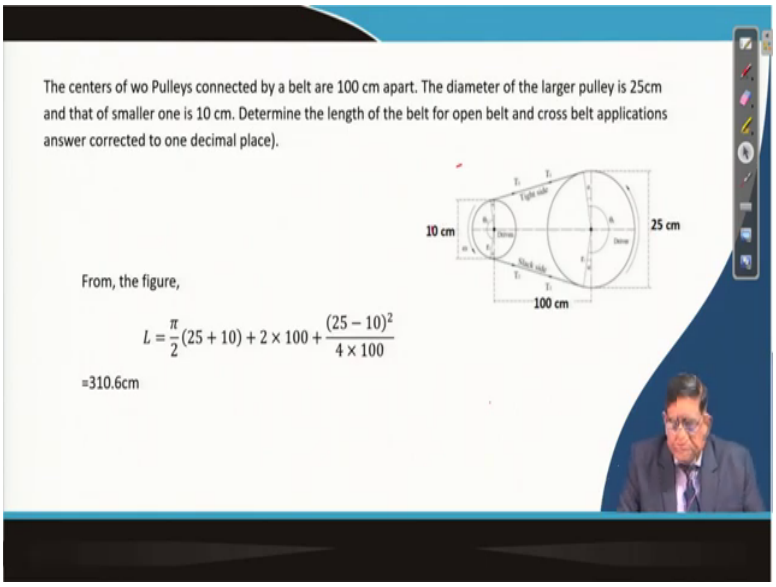

So, now let us try to resolve this numerical problem that what it says the center of two pulleys connected by a belt of 100 centimeter apart. So, this is a two pulley. They are connected by this belt and their distance is 100 centimeter apart. The diameter of the larger pulley is given 25 centimeter and diameter of the smaller is given 10 centimeter.

So, now if you have to what will be the length of this that is your belt this belt length is a that is what is very important one because in any particular installations if you want to that select a belt drive you can have the that already there are number of belts or length of belts are available in the market. From there you want to select one and put it over here.

So, you need to know at what distance they will have to be separated and whether that ratio will be giving you the proper per requirement or not. So, that type of applications that is why you need to know in a particular installations how to calculate the length of the belt. And, this

length of the belt can be calculated from the just from the geometry you can find out that is your ultimately these equations will give you the belt length.

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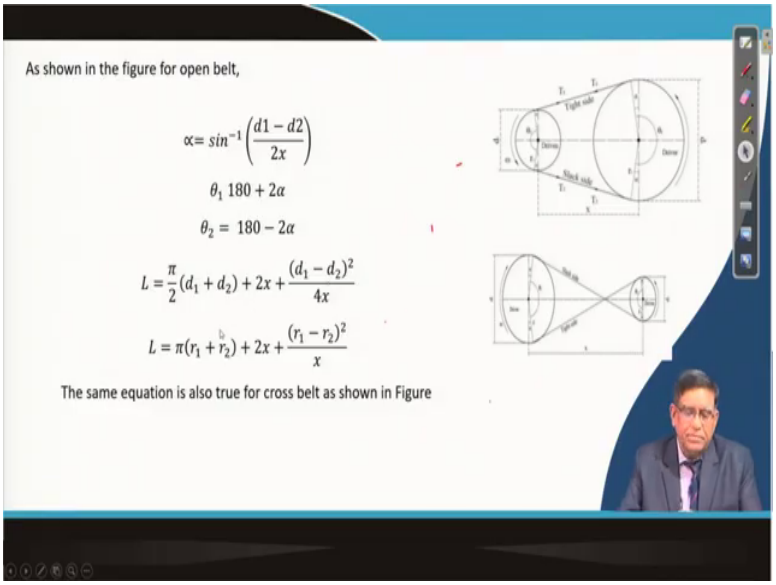

Similarly, here we have got another problem that is you can calculate out that this lengths for different type of this as system. Say, exactly if it is for your open type or if it is a cross type, will the lengths of the belt will be different. That you can calculate by using this equations.

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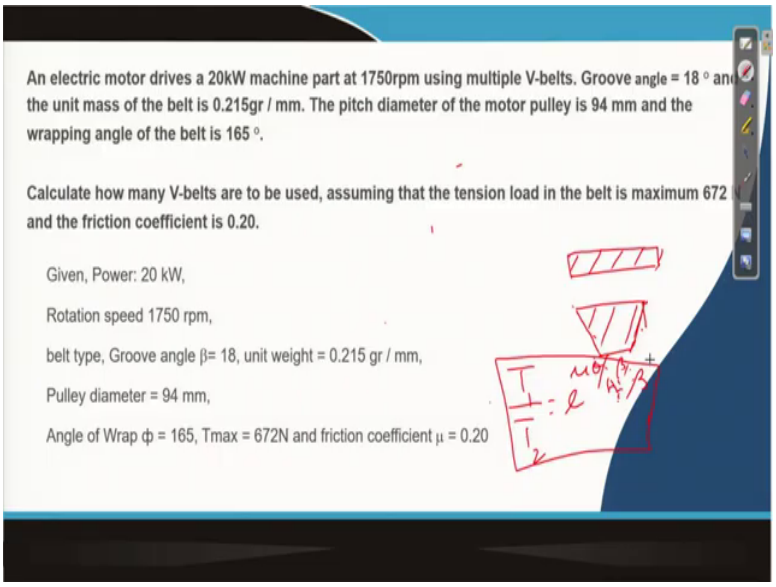

So, you can write down another problem. There is an electric motor drives a 20 kilowatt machine part of 1750 rpm using multiple V-belt. At a groove angle is 18 degree and the unit mass of the belt is 0.215 gram per millimeter. The pitch diameter of the motor pulley is given 94 millimeter and the wrapping angle of the belt is 165 degree.

Now, one thing you need to know here that is when it is a V-belt, V-belt is a different type of belt. Here exactly we are having the belt is normally the belt is of this cross-section. Now, when a V-belt it is exactly there will be a groove type of things exactly the belt cross-section is this type. So, that means, there is a groove angle is there this is called angle say beta.

So, then this your in a belt here T 1 by T 2 this will be given mu theta by sin of this beta. So, this is the belt tension in case of this your v belt that mu theta by sin beta, this portion is to be noted down. So, that means, whenever this calculation is coming for V-belt this which is very

common in use. Say for example, most of the power transmissions in your machines components you will be getting V-belt not that flat belt.

Now, this what is here in this particular problem it is given in this particular problem your first try to find out the given data that is your power is given that speed at which it is rotating it is given that belt type is given. It is a that is a groove type with a 18 degree groove is there and then your what is the belt weight mass that is mass per unit length is also given and the pulley diameter is given.

So, when your angle of wrap that is also given over here, then the maximum tension is also given. So, that is your coefficient of friction is given. So, you can resolve this problem now. How will you do it?

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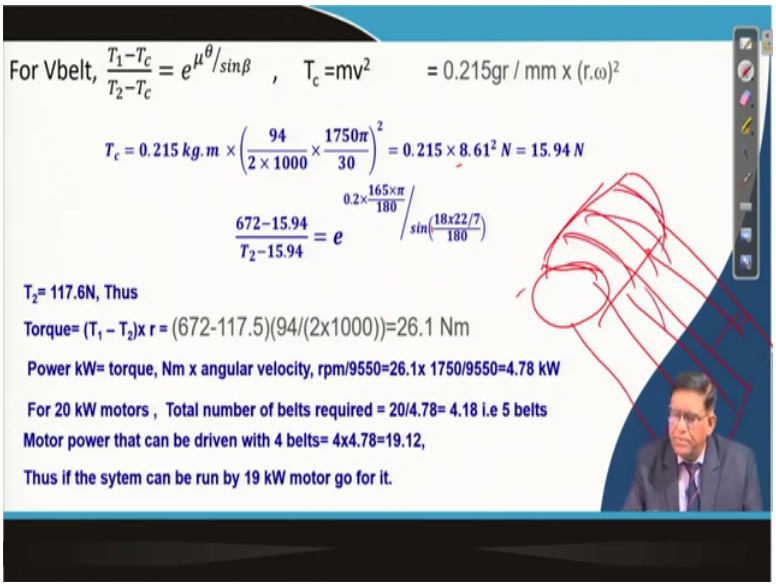

So, we know that there is a this in a real life your why that mass is given that is a that mass per unit length is given. So, you can find out what will be the centrifugal action because centrifugal action depends on you know that is mv square. So, you can calculate mass is given, velocity is given, T c can be found out.

And, then for the ratio tension that is tension ratio is T 1 minus T c because this is the centrifugal action is there and in place of your e to the power mu theta will have to take e to the power mu theta by sin beta. So, that means, from here you can calculate out what is T c that is your the centrifugal action is determined.

And, once you determine the centrifugal action then by putting this term in these equations then you can find out what is your this T 2; that means, in your belt the tension will be coming. Now, once you know this T 1 and T 2, then you can find out the torque; torque is nothing, but that your effective tension into the radius. Radius is also given. So, that ultimately you know the torque.

Then what is the power required? That is power is your torque and into the angular velocity. Now, in this case this angular velocity your rpm is given. So, if you use this formula given for power, you can easily calculate out what will be the number of belts required.

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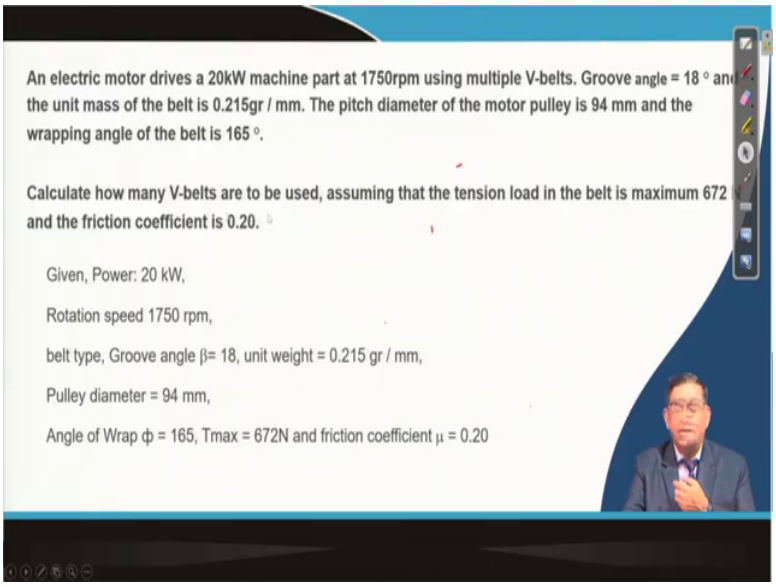

So, that is in the problem it was given that is your calculate how many V-belts exactly in a in a belt V-belt drive you may find over here that is exactly from that. If you if you are having a pulley like this so, this there will be number of grooves here and then this belt will be going like that number of belts will be there. So, that that means, your this whole power so, that number of this V-belt will be providing the power.

Now, for giving that one you can find out that the power which has came it is coming to 4.78 kilowatt can be the power by one belt so, but you have got a 20 kilowatt motor. So, when you are having a 20 kilowatt motor, then you will have to use if you as because it is just like unitary system one gives 4.7 78.

So, for 20 kilowatt motor it will have to have 4.18 belt, but belt you cannot make it as a fractional number. So, that means, you will have to go for 5 belt. Now, the question is that is

your if there were 4 belt, you could have gone 19.12. So, will you exactly then what you will have to do in a design you need to check because you are using the if you are going for 5 belt exactly the additional belt giving a power you are not going to get much.

So, in such type of situations what you will have to do is you will have to take if you can do the operations by 19 kilowatt motor or not. So, that is way how in a design part you do a little bit of iterations to get the things to done. So, but the basic principles of how exactly the tensions belt tensions are used for determining the power and then determining for a drive, how many number of V-belts you will be using can be given over there.

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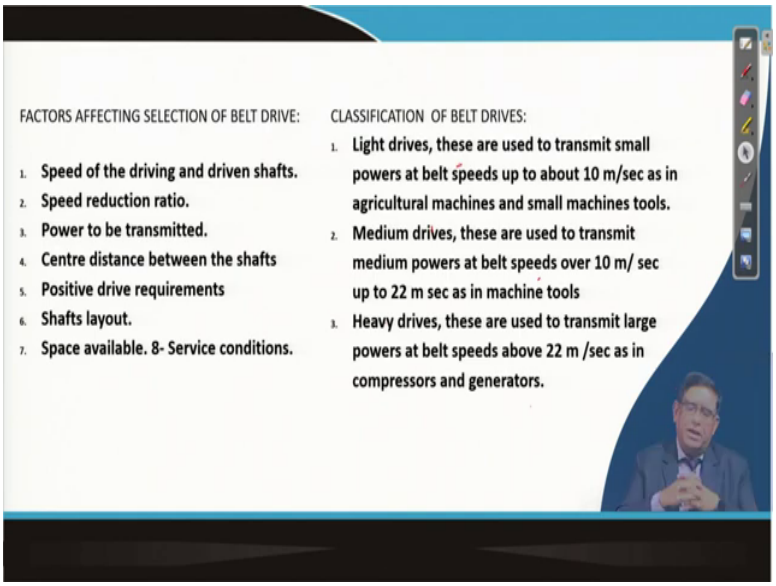

So, there are various factors which affect this belt drive selection. Basically the speed of the driving and the driven shafts, so that speed ratio is very very important, then how much power

is to be transmitted, then center to center distance as I have said then the positive drive requirement that is drive will have to get exactly connected directly to the that your shafts.

Then this how the shafts are layout; that means, in how the space negotiations will have to be there that. Then you will have to also how can be we classify this belt drives in the market there are different types of belt which can be your light drive and can be your medium drive, there could be heavy drive like that.

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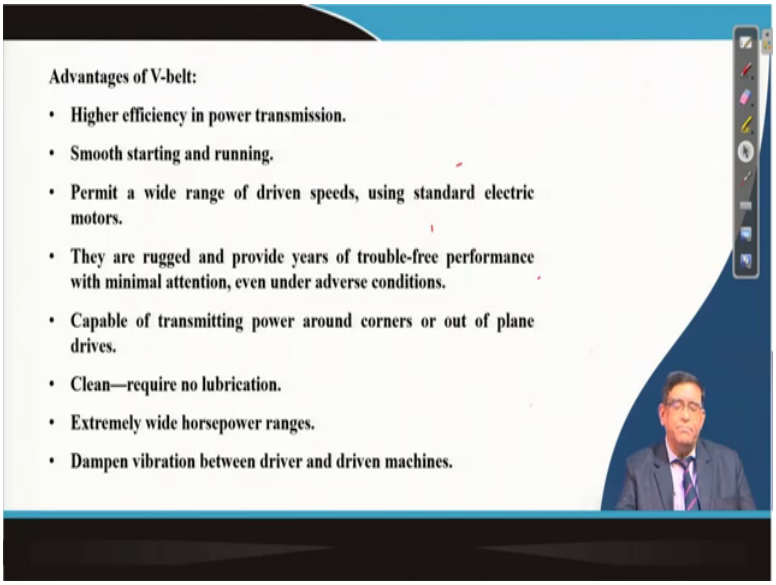

So, there are number of advantages of V-belt you can get a high efficiency; smooth starting running and that it permits wide range of driven speeds; there are also it is a very clean. It is they need not give that your lubricating oil and all that thing in gear. So, that is why it is having less maintenance.

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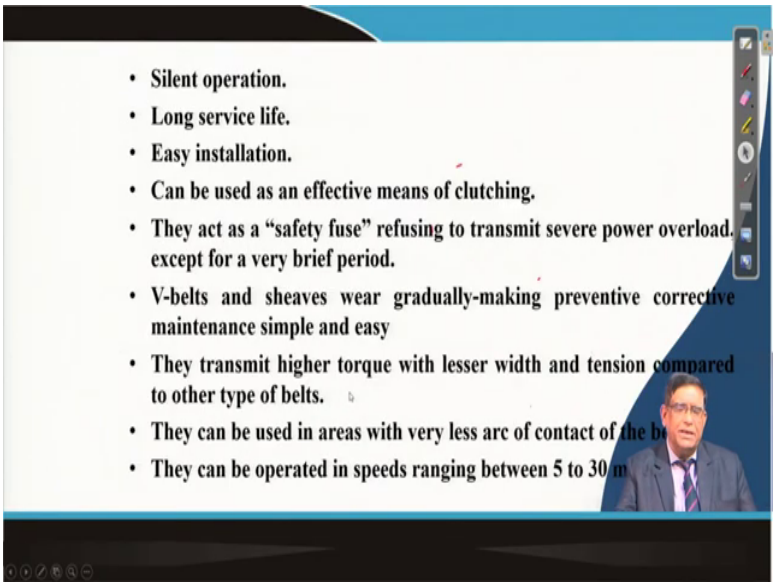

It is very silent in gear because of the metallic parts will be moving you get. So, you may find out lot of advantages are there.

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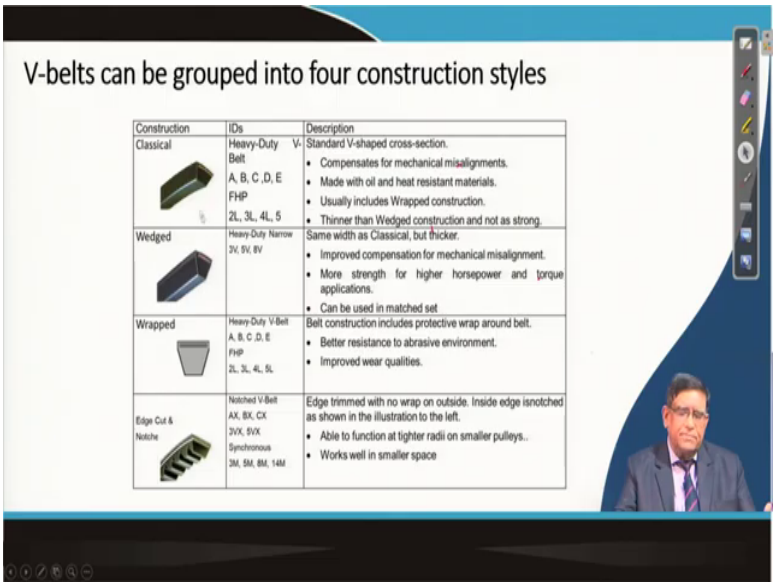

And, these are the different commercially available. V-belt you can see a design data book or that this type of belts, then what are their purposes and all how they are classified you can find out.

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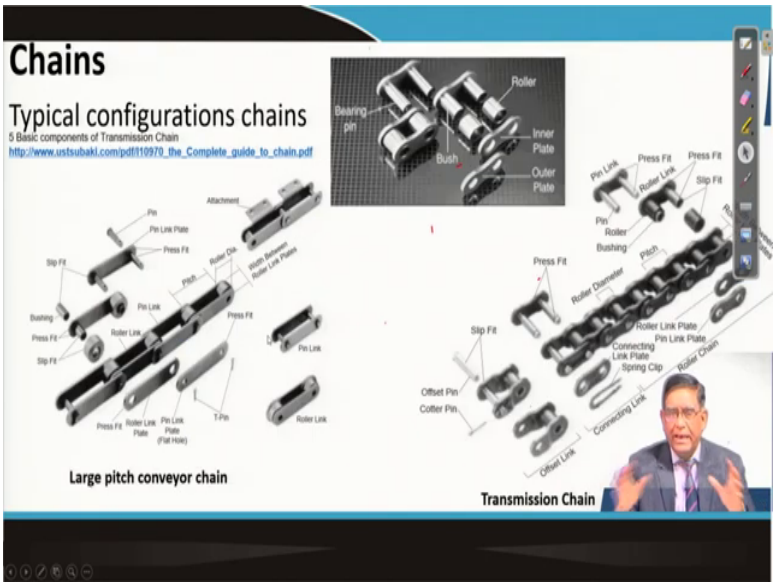

Then the in case of chain drive it is a there are mainly five components in a chain, that is, there will be some bush, there will be a roller, there will be bearing pin and then there will be a inner plate and outer plate. They combine together depending on your long pitch you can see that this is a longer length this type of pitches are there to make chain and there are some transmission chain in which very smaller type of things you can you might have seen this type of chain in your bicycle.

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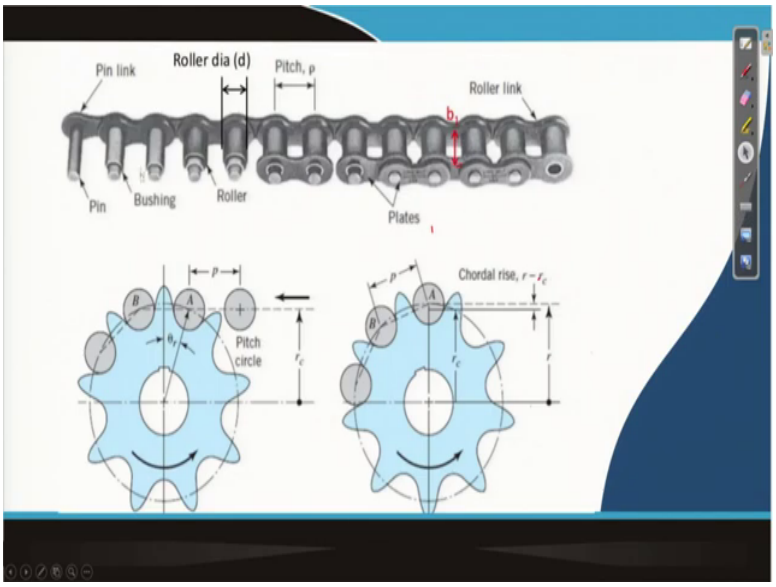

Now, whenever there is a chain drive this chain will have to be that distance between these two it is called the pitch you will have to make the sprocket in such a way that your this is matching over here. So, this arrangements of chain is there.

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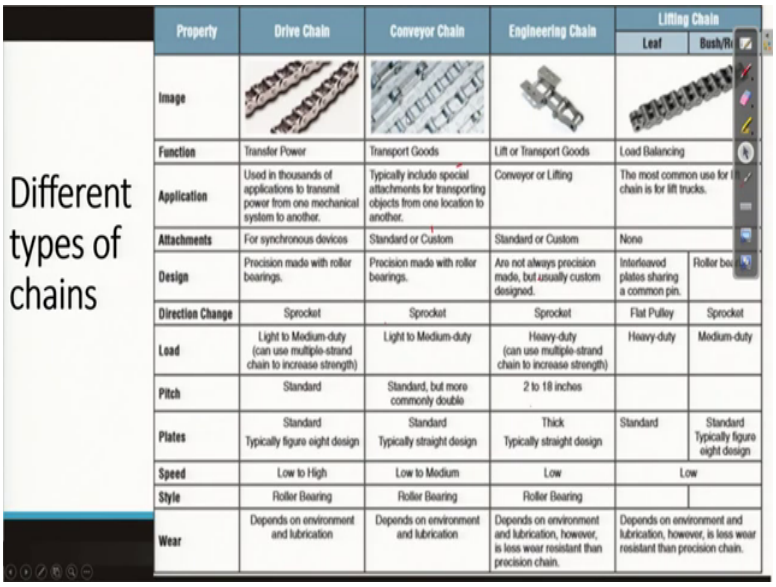

And, there are quite a large number of different types of chains with just right from your that your watch chain to bicycle chain to some of the industrial chain. But, that properties mainly there what function they are used, what applications they are there, what type of attachments are made to it, what type of design you will be doing for and then the how whether you require a directional change or not, how much load will be coming, what should be the pitch and then what type of plates will be connected, depending on that number of different types of things are used.

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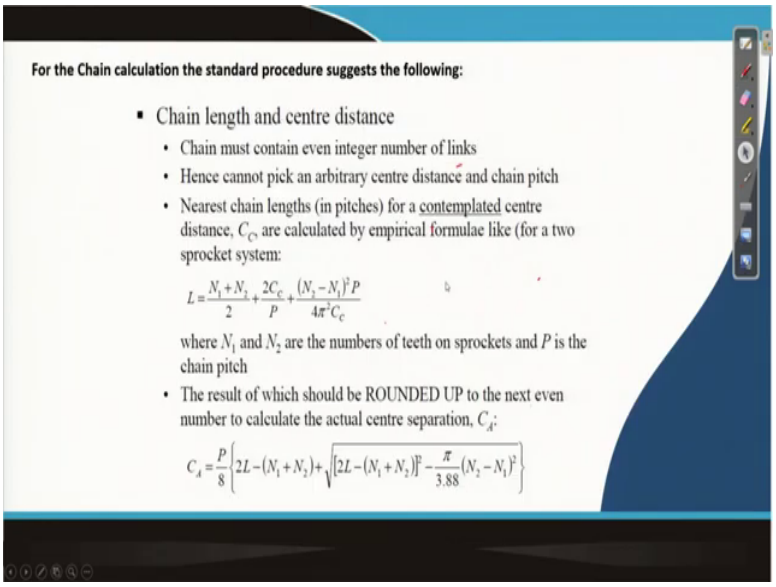

Now, for calculation of the chain calculations you need to know that what is the nearest chain length. For that calculations if you know the that your chains driving and driven ratio and then if you know that center of distance and if you know the pitch then you can find out what will be the length of chain required for your.

Now, that is why this is one of the important calculations. Similarly, that is your the results whatever you will be finding out you can find out the center separations can be determined by this equation. So, normally you will have to do it.

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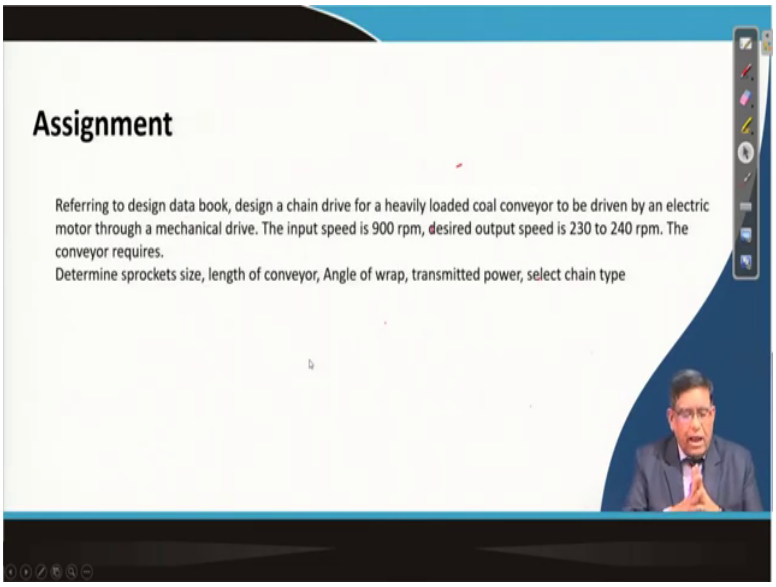

And, that I wish that you do a exercise as an assignment that is design a chain drive for a heavily loaded coal conveyor to be driven by an electric motor through a mechanical drive. The input speed is 900 rpm output speed is 230 to 240 rpm that conveyor requires. This is for that purpose you determine the sprocket size length of the conveyor angle of wrap transmitted power and select chain type.

So, this ones you will have to do as an exercise by following design data book of for chain conveyor and there are many other references are also available.

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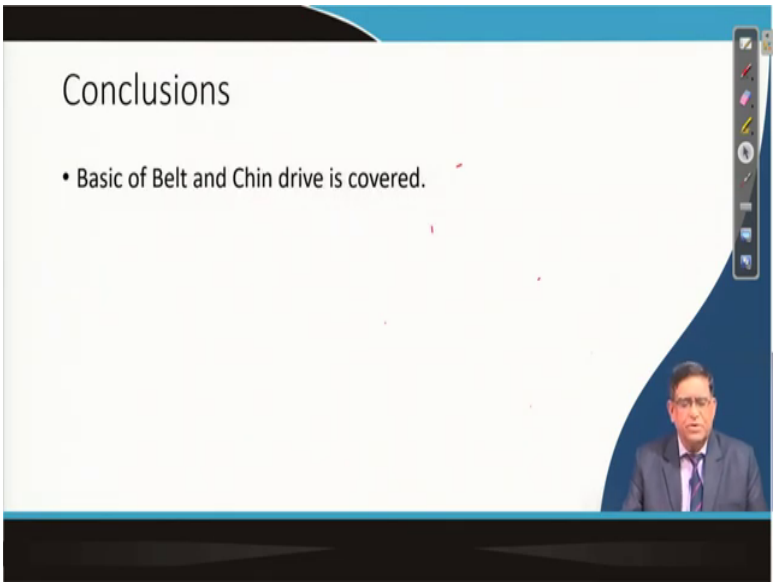

But, here today we have just discussed the basics of belt drive and chain drive.

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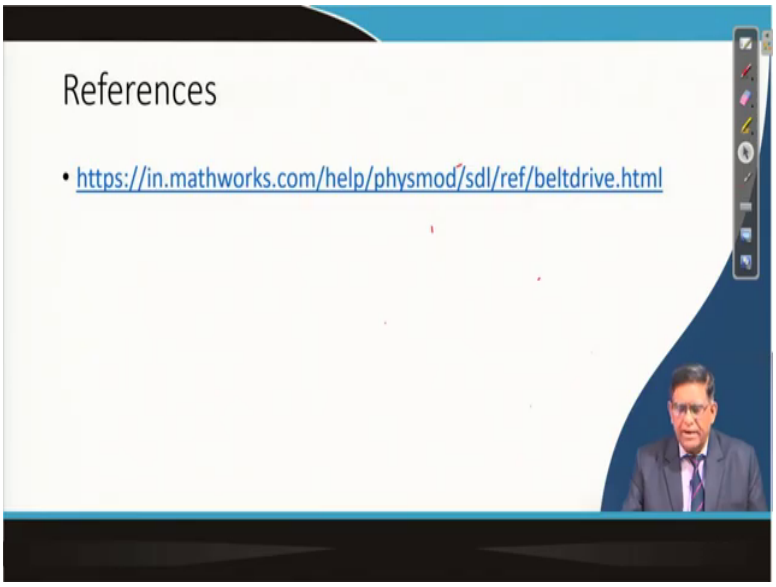

There are some differences available over there and I hope if you go through that and do this exercise, solve the problems and take some your own as an assignment if you do a small design then you will be learning what it is there.

And, in the real life we will have to understand that how this belt drive and chain drive are used in different machines and for different transportation job and then how they are maintained. We will be discussing those when we will be going to discuss the special mining machinery for it, that maintenance aspect we will discuss it over there.

With this, thank you very much for listening.