Mining Machinery
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Module - 10
Lecture - 56
Mechanics of Hoisting

Welcome back, we are discussing this underground mine transport on that we have already discussed about hoisting and winding. Now, you know that this hoisting and winding is a very vast subject in the sense if you go for designing right from the headgear design to the whole this calculating these ropes, then motor power and all there is a lot of analytic analysis can be carried out and then there could be a lot of design problems can be taken up. But here the we need to have is some basic understanding of what is hoisting calculation.

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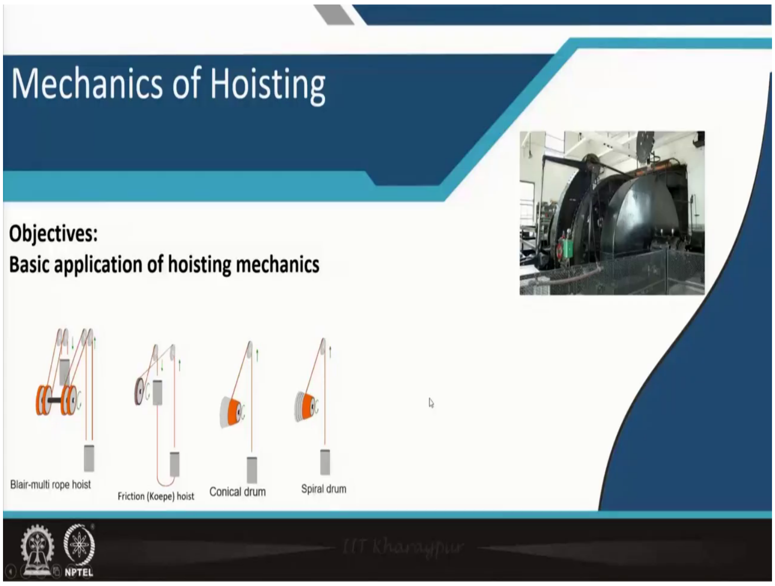

So, as a with today, I would be just telling you about some basic application of hoisting mechanics, that means how this different calculations are carried out. Now, as you know that these drums and these sheaves these two are the main thing and then the ropes whether it is a Blair multi rope or the friction Koepe or the conical or spiral drum.

Now, the whole mechanics and kinematics of these systems that trigger a systematic study. Now, basically you need to know say for example with the depth increasing you will have to accommodate more rope, if we were to accommodate more rope than your this drum which will be increasing, then here when there will be number of route turn how many maximum turn you can give. Then when you are using a say drum then if you are having a sheave that is your what will be the fleet angles and all those things to certain some things we discussed in the previous class.

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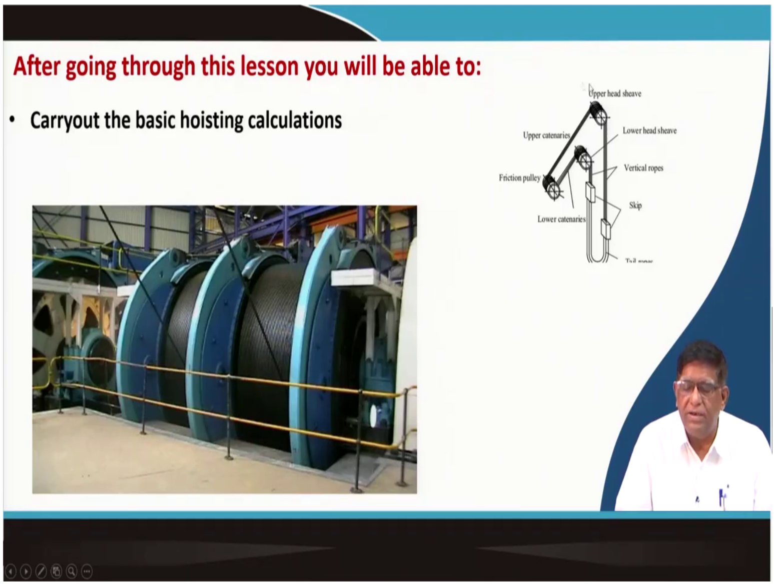

Now, let us see here that say when you are to carry out how will you carry out the basic hoisting calculations? Now, that it could be a drum winder or it could be a Koepe winder where your either case or skip can come. You know these basic components that is whenever your drum or that Koepe winding is carried out your mainly the rope drum the pulley and this arrangement this is a basic arrangements of mine hoist.

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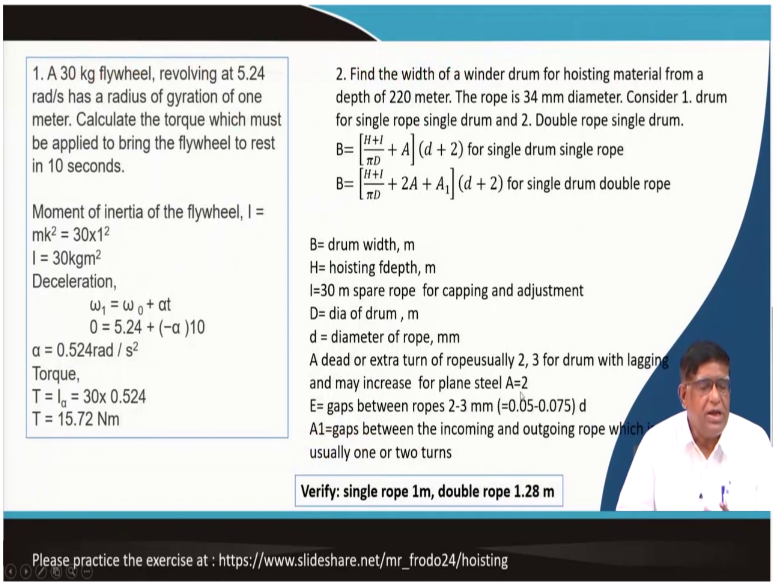

Now, let us go by a some numerical, let us say that first thing is you need to know the torque, that means if you are having your; if you are going to have any these hoisting operations in which you are having a that tells your this drum.

Then when it will be rotating in this direction then exactly how much torque it will be coming on that is when your this drum will be rotating. At that time you will have to determine first the torque is the general basic concepts you know it is a very simple things.

Take a small numerical a 30 kg flywheel revolving at 5.24 radian per second that angular velocity is given and the radius of gyration is given say 1 meter. Then how will you calculate the torque? Here the basic very simple equations you know that the moment of inertia of the flywheel is nothing but mk square. So, mass is given and that your radius of gyration is given you can find out the moment of inertia.

And then what will be the that you know the acceleration this formula, if you know that angular velocity omega 1 will be at a particular point omega naught plus acceleration into time. So, from there you can find out what will be the accelerations. Then your you can find out that torque from this moment of inertia into acceleration that will be giving you the torque. So, the torque can we find out from this relationship.

So, like that in whenever you have to the basic your physics need to be known. Now, another thing is if you are having a drum, then exactly what should be its width? Now it is a you can easily use your common sense that the width will be depend on what? Width will be depend on how many exactly turn off or what is the length of the rope?

Because if we are to accommodate more rope and exactly that while winding you do not allow more than the sensor a number of turns, because if you put more turns, then because of the turn below that rope will be getting stressed and then they will be getting damaged and then the whole that reliability of the system will reduce.

So, for that exactly the factors are if you have to calculate the drum width it depends on the hoisting depth. Now, what is that how much is the hoisting depth that is your that shaft depth from what level it need to be taken out? So, that means if you know the depth or that where is your pit bottom from the then you need to know that every time it is not only the depth part alone what you will have to do?

You will have to have your the some additional turn about 30 meter square rope. You take that is for the capping at the bottom that having interconnected at the that is a termination rope terminations will be given in the drum. And also sometimes you need to give some extra length for if you have to take a some piece taken out for testing and other purposes, then sometimes your tension adjustments and all that things.

So, you need to keep about 30 meter additional length. Then it will depend on what is the diameter of the drum, then your diameter of the rope these are the factors that affects. And then there should be always a certain number of turn on the drum. So, that is called your dead turning or dead rope on the drum.

If all this thing is there then you need to know whether they that you are having a single rope single drum or in the previous class we told there could be a single drum and there will be 2 ropes will be going. So, that means you are winding one is winding up one is winding down that is in that case what we will have to do?

This 2 rope will have to be accommodated at two part. So, in that case the drum it will be a little bit more and then in case of your single drum, single rope this is the calculations you make it very just only by undertaking into account of all these factors. And if it is a double rope that is in case of double rope your this the extra they turn it will get doubled up and also there should be a gap between that is your say lifting one and that your the lowering one between these two there should be a gap. So, this determines what will be the length.

So, you can take this is find the width of a winder drum for hoisting material from a depth of 220 meter and the rope is 20, 34 millimeter diameter and consider the drum for single rope. If you are taking a single rope then what you will have to do? This one’s and your when you calculate the weight you can find out the result is given as a verification. So, please calculate it out and check whether you get these results or not.

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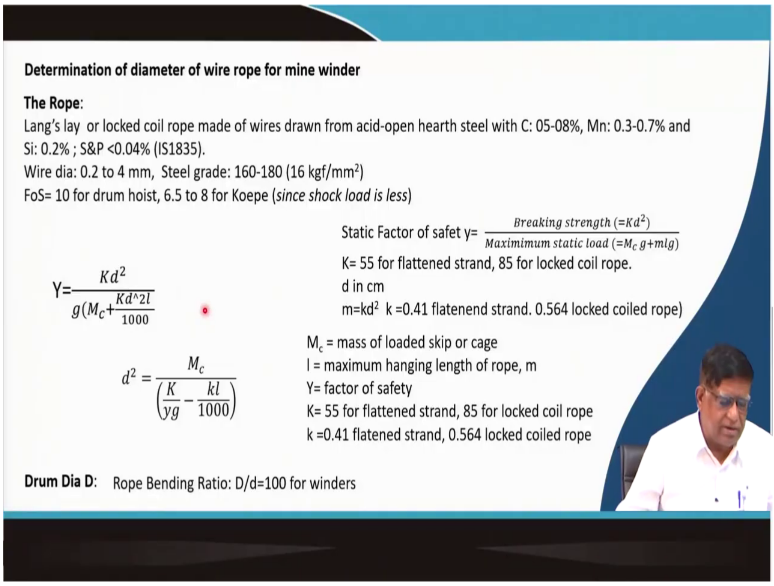

Next is your say how will you determine the diameter of the wire rope of a mine winder? Now, this is another very important thing in case of winding you will have to select the rope. Now, one that is what is the power required to drive? The power required to drive is the whatever the total load is coming that will be the giving the whole resistance.

Now, if you are to carry out from a particular depths, then depending on that if your diameter is more exactly that whole weight of the rope will be giving another extra load than your material. So, that is why if it is whatever is the diameter required you should take this otherwise unnecessarily you will be giving additional load on your motor electric motor or we can say otherwise that is your system will not be energy efficient.

Now, let us see how you calculate this rope. Now, you know that Lang's lay an ordinary ray in your wind that you are still rope wire rope lessons we have discussed and there two factors are very important regarding what is exactly called mass factor that means, your the breaking strands of a rope that depends on one factor that K and then d diameter of the rope.

And then this K value it depends on that type of rope if it is a flattened rope that is good K is equal to 55 and if it is a locked coil rope that K value is 85 that means, you can say that that means who a, which has got the higher breaking strength because definitely the locked coil rope because there the compactness is more.

And then another there is a mass that is how much will be the that is your mass is given by another that is mass factor is your small kb square. Now, this k value also you can see that flattened rope it is 0.41 and then it is 0.564 this. These two factors are important for calculating this rope dia.

Now, whole thing is depending on what will be the, your factor of safety. This breaking strength and the total load which is coming over there, the total load which comes of this is exactly the mass of the your loaded skip or cage plus that mass of the rope that as a mass per unit length we can find out and then multiply by the length because one will be going up one will be going down. So, twice that length is there.

And that mass is given in kg you convert it to ton and then this is the way you can find out that this is the total load coming and this is your total your this breaking strength given and their ratio is the factor of safety. Once you know that factor of safety in other way you can find out this will be as a function of your d square you can calculate out, which will be you can using this formula you can find out what will be the rope diameter.

Now, is it clear now, that is exactly the determine the rope diameter for a particular winding installation you need to know that what will be a total load being lifted. And then your this is we are not considering few things here that is any other additional stress and loads are not being taken into considerations. So, that whatever other may be coming you define it in the factor of safety.

Normally, for man winding and all you will be taking factor of safety 10 and in case of your material and other you will be taking factor of safety as 8 and with that you take care of some of the other resistances, which have been not considered in the load, here we are taking the load only on the skip cage and the assessments and the ropes width.

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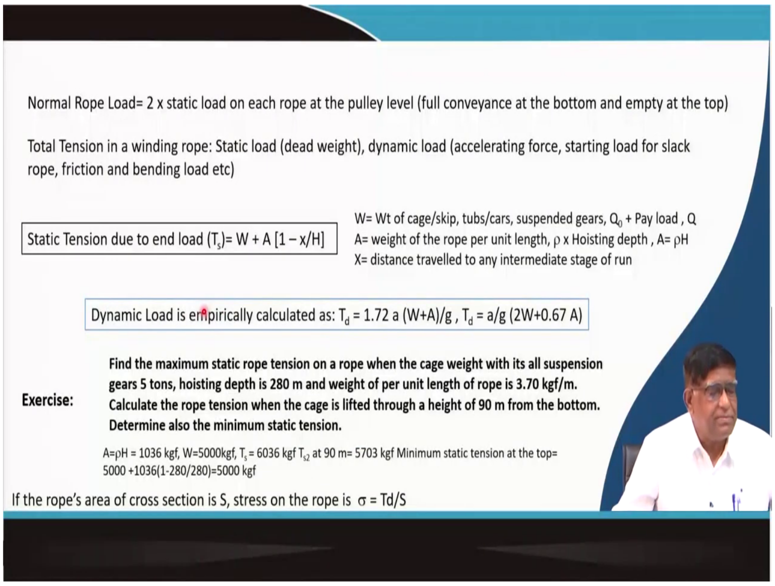

So, this is the way you can calculate it out. Similarly if your what is a normal rope load it is the twice the static load on each rope of the pulley that is called your normal loop load. So, you can calculate that out. Now, total tension in a winding rope it is basically it is contributed by the static load and also the dynamic load when it is coming with a motion then it gives also certain load on that that is your when it is accelerating you can find out that is a mass into acceleration will be giving an accelerating force.

And also if the rope is an having a little bit of looseness as slack is there then when you start moving it will be giving a shock that is a loop is there that loop get tightened at that time also another load comes. So, there could be different type of loads which could be coming.

So, but in general if you have to calculate the static tension at the end of the load what it is done? You need to take the weight which is suspended that weight suspended will be depending on what is the your payload, that means how much exactly your additional material you are giving and what is the tare load; that means, what is the total empty vessels or empty cage or with the empty tub their total load is the.

So, these two that Q naught and Q these are the your it gives a total weight on the cage. And then weight of the rope per unit length that a and then you multiply by the total length. Now, there is one factor you have taken that is you can see here this is your distance travel to any intermediate stage of the run.

So, that how much exactly getting suspended from there it can find out. Now, this is the total static load; that means, whatever the suspended and whatever the load coming to that which exactly if you want to turn that will be working as a force that multiplied by the your radius of the drum it will be giving you the torque over there.

Then dynamic load it is exactly during the motion that how much exactly the load will be coming that is it is being raised acceleration due to gravity is pulling down. And you are giving an accelerations by the motor these two terms taken into and you consider a dynamic load as it is given over this formula.

Now, just try to do one numerical here please write down. Find the maximum static road rope tension on a rope when the cage weight with its all suspension gears is 5 tons and the hoisting depth is 280 meter and the weight per unit length for the rope is 3.7 kgf per meter. Now, this calculate the rope tension when the cage is lifted through a height of 90 meter from the bottom determine also the minimum static tension.

So, as you have if you put the values into this then you can find out. Now, if you know the area of cross sections of this once you know the area of cross sections and then you know this your total tension coming then you can find out the stress by the tension dividing the area. So, this is how you can do a basic rope calculations in a winder, right.

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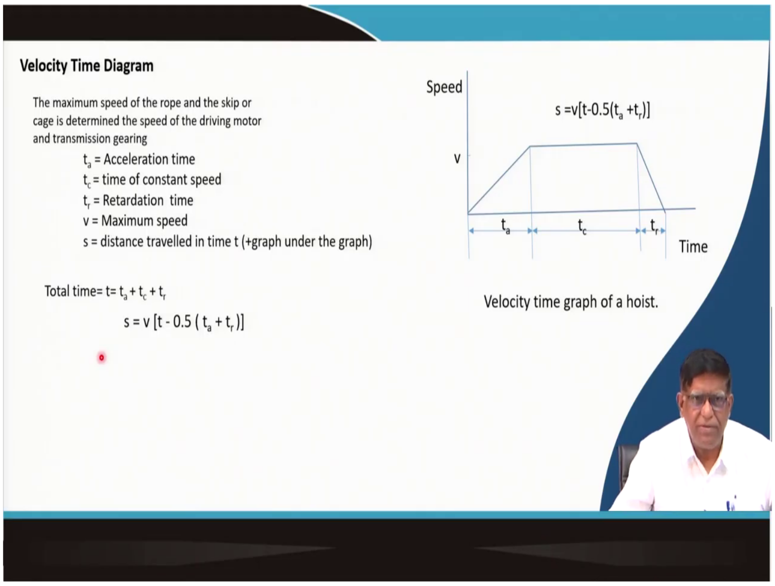

Now, certain few other things is very important almost all in any installations you want to go to the mines you can find out that what is called your velocity time diagram. Now, the cage which is there that will not be all the time it will be just it does not get the maximum speed just as soon as you start, there is an acceleration time and then there is a your constant velocity time and then there is a retardation time this three time it comprises the total their travel history of the cage.

Now, depending on their trajectory if you plot them in a area like that then what is this distance travelled by that? The distance is nothing but the area under this curve. Now, this area of this triangle that will be the distance travelled during the acceleration period. Area of this rectangle will give you the distance travelled by during the constant speed period and the area of this smaller triangle will be giving you the distance travelled during retardations.

And then you can easily find that out that is what will be the total distance just you take it is half v into t naught then this will be your this distance and that is a v, this term v into t c and then you are having this again half your this v into this one. Now, combining this together you just a little manipulations you will get this type of equations for the distance travelled.

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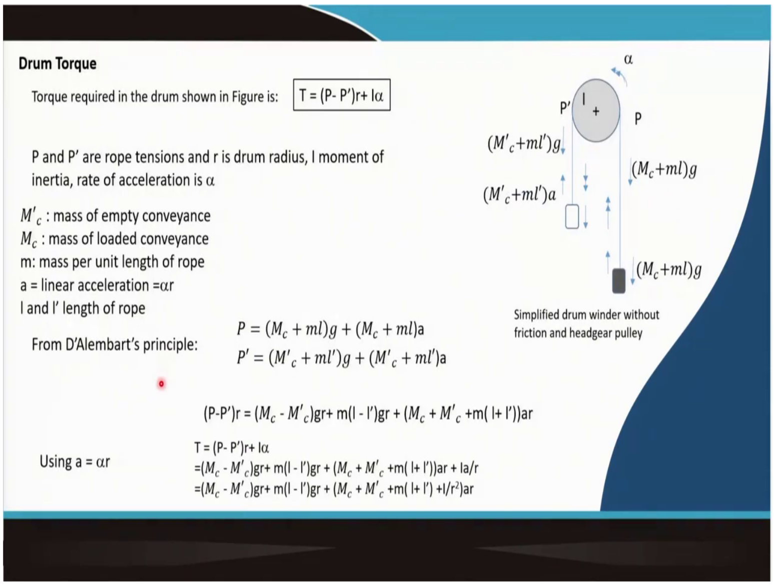

Now, once you know this the basic principle you can find out that what will be the drum torque coming that you remember that flywheel exercise you have done. Now, that same thing you come to a situations, where you are doing in a winding. In a winding what you are doing?

Your one cage this is a loaded cage is going upward at that time your a total mass of the empty cage and the mass of the load and the mass of the rope that is this total mass here and the mass of this rope it is multiplied by g is the weight which is acting downward. And that is your this your M c plus this ml this is acting downward, but the whole material it is going upward because of the power given over there it is moving at an acceleration alpha.

Similarly your here there is a the acceleration this one when it will be going down, there will be a this acceleration force will and that this a weight force that will be working downwards. So, these different forces and all if you find it out, then what exactly the you have learnt about that D Alembert's principle that is exactly that total sum that is your Newton's second law if you write it as a 0 equal to P minus mf that is exactly if you apply over here then you get these two equations for the two sides.

Now, if you combine the errors or subtracting from there you can easily find out this equations giving you that your what will be the torque coming over here, because the torque is nothing but that P minus P dash that is that effective tension into radius. Now, this the effective tensions by this simple subtractions they give you the things. So, now you have understood that drum why you need to know that that torque only when you give that at that time it will run.

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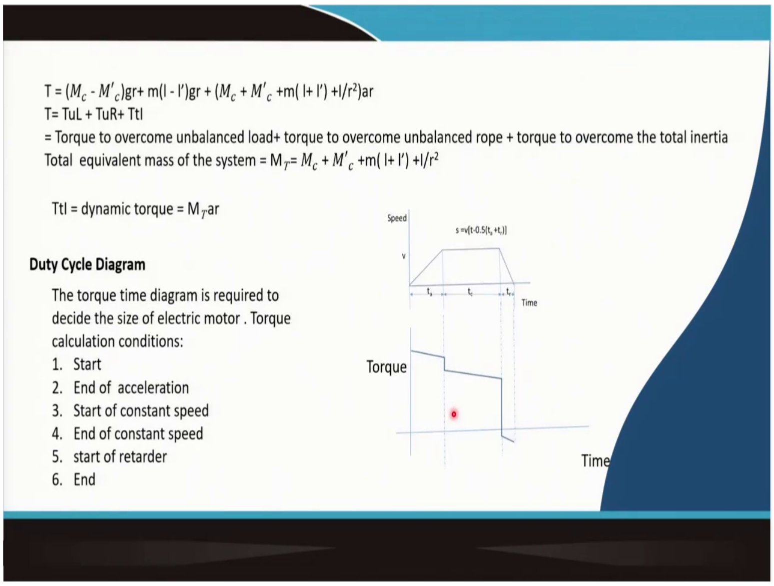

So, once you find out this torque, you can find that the values we can draw a torque time diagram. In any winding situations this is called your duty cycle of the that your that winder and then your this torque will have to be applied by power. So, you can have a power time diagram you can draw for this.

So, in a nutshell that is your the dynamic torque which will be coming at every moment it will be changing because of the situations of the winding at what stage it is coming as it is and then how much load it is being load is being lifted.

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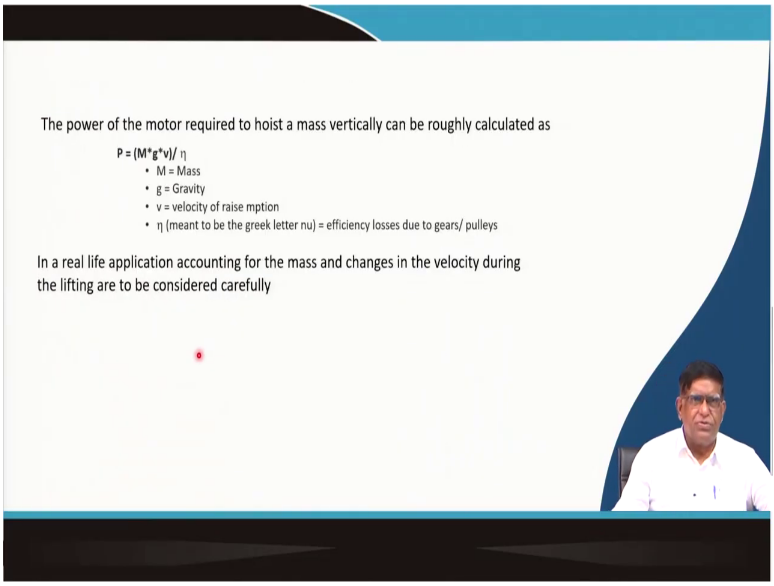

So, this is one part you should know, then the power of the motor that is the main purpose of your whole calculation is to determine how much power is required, if you now know the mass you know this gravity and you know at velocity at what you will have to raise, then very simple motor power equations that by considering efficiency factor you divide these things that will give you that much of the kilowatt or what the power is required for doing this operation.

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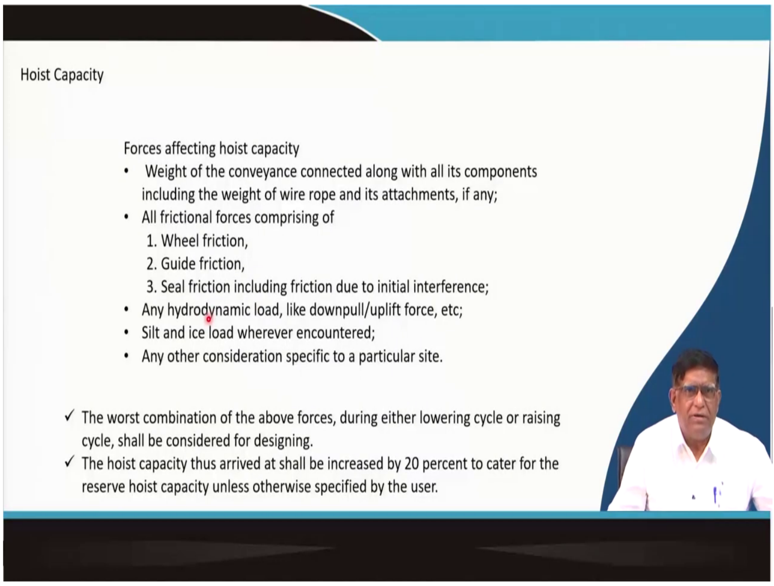

So, then other thing is your how much exactly will be the hoist capacity? That is a hoist capacity it is a it will have to take into account what are the forces it can overcome. And then there is a the frictional forces at the wheel, at the guide, at the silt and then there will be a hydrodynamic load like your down pull up will force.

Then if on the rope some the neck winter country they are cold country, ice may get stuck or may dust may got stuck about that they will be giving some load. And then any other parts is a suspended from there all these things will be giving. So, now the capacity calculations means what should be the total power rating we can determine after knowing all this total load or total tensions coming over there.

So, the worst combination of the all these forces is normally taken for calculating or designing out that what will be the power requirement. The hoist capacity is arrived and shall be increased by 20 percent additional. So, that any overloading or any over winding conditions it does not break. So, that means while designing your philosophy is to take utmost precautions for this model.

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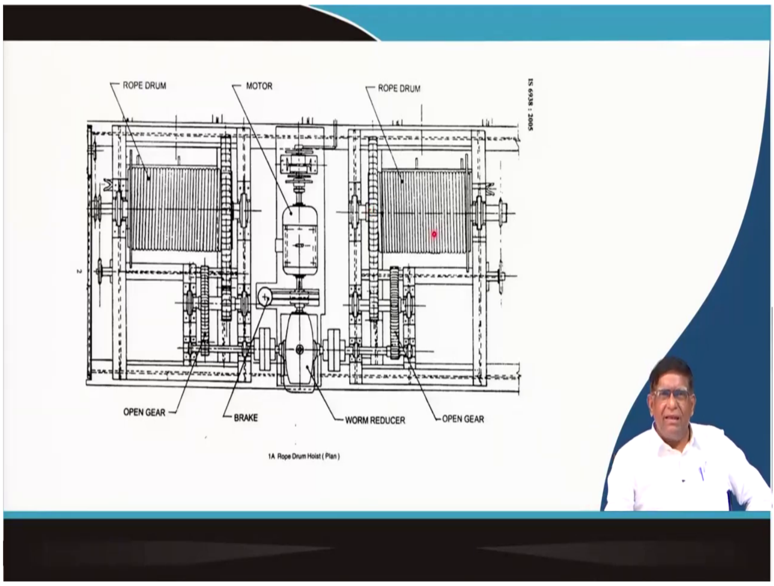

Now, coming to that if this is there that you have understood how it is arranged in a field. You will find if there are 2 drums these 2 drums are being shoved by one motor you can see that it is giving to a worm reducer it is connecting to this reduction gearbox, from here this is going to this pinion and from this gearbox it is coming to the it is the drum on the drum its flange it is a gear which is engaged with this gear.

And then we are getting the drive to this rope drum like that in the same similar thing is also here and this. So, this should give you what you look like, if you go to a winder house your main winding rope will be coming over there this drum. Now, this drum will be supported on some bearing board and some bearing will be there. Now, what type of bearing and all it is again decided the mechanical engineering load, how it will be coming, it can be push bearing ball bearing or hydrodynamic bearing these are.

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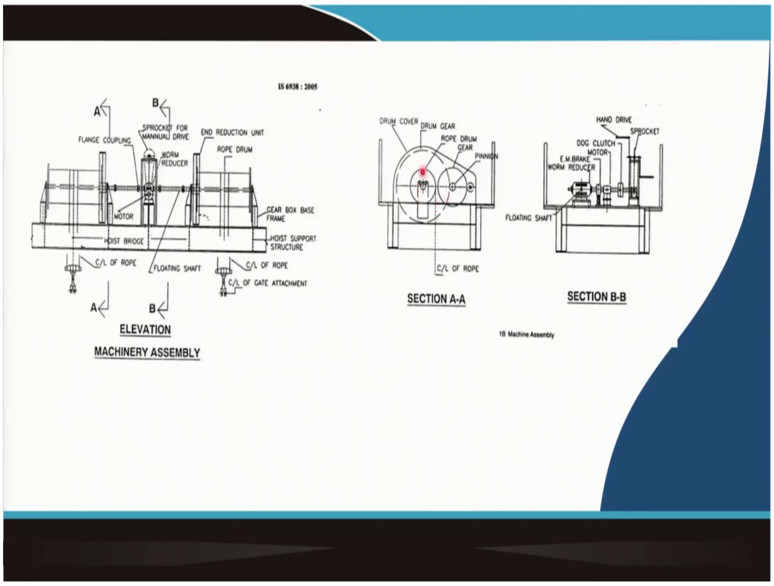

And they if you see this situations there, your from the this from the front view you will see that that elevation part, your these two are the drums there will be on the drum there will be brake and then there will be the driving motor. And then if you see from the this one side it will look like this that is your the driving and the driven wheel and then whole arrangements can be made like this. So, this gives exactly when you have to get a winder design and then winder capacity calculations this starts from there.

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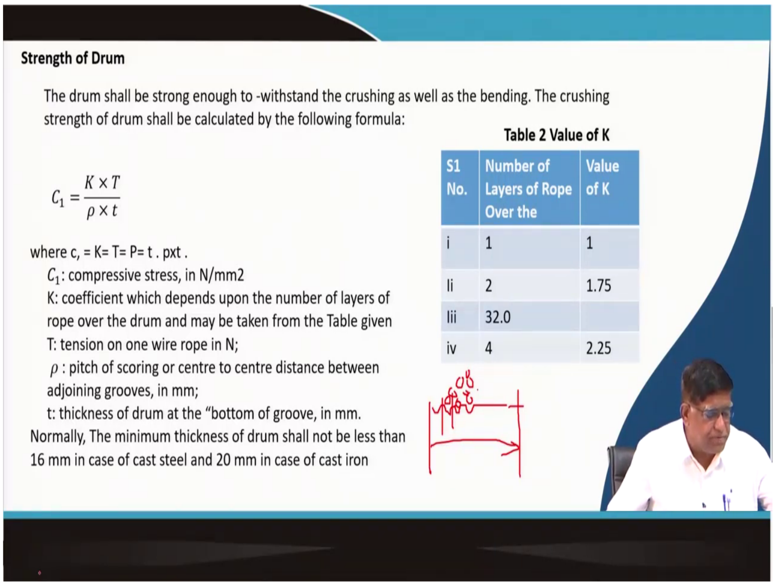

So, you should have an idea whenever you will be visiting any winding installations you will have to see that this drum which just now you have seen that must have that sufficient strength so that it can withstand all the load coming on it and is that for that what is required? The drum material selected and all they should have the required compressive strength should be there.

And that compressive strength it will be depending on the coefficients that depend on the number of layers on the rope, if you have moved the layer and then total tension how much it is coming. So, if there is this K coefficient on the different number of layer it is a if there is only one layer of rope is there on the drum coefficient is 1.

But, the maximum which can go in winding it can go 4, that is over there only 4 turns of ropes are there then our value of K will become 2.25. So, then your this row is that pitch of the scoring or center to center distance between adjoining grooves. So, there will be these grooves on the drum you will find that in the normally the drum surface there will be like that the groove will be there.

So, on which this exactly the rope will be coming over here. Now, this center to center distance of the groove is very very important, that means how many rope will be coming over here like that, that is turned and during this part is the your width of the drum.

So, if it is a single drum and then this rope is getting turned over here and then the maximum it can go this 3 and then it can go 4 where in that case the value of K will become 2. So, that means on a drum how much; how many layers of your rope can be put that determines your the strengths of the drum will be affected by that. And that if your pitch is more you will find that your strength of the drum will be less. If the pitch is small the strength of the drum will be increasing as you can see from this equation.

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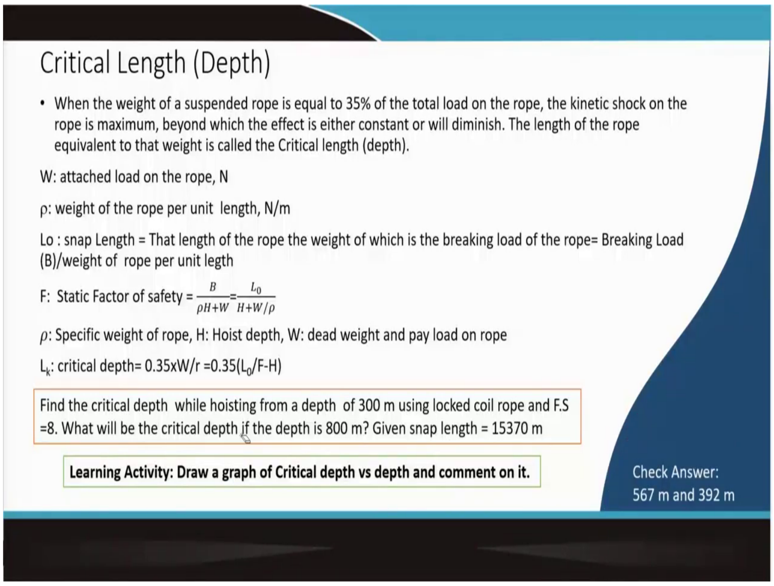

Now, then few other things from the hoisting principles you should know that what is the critical depth? Now, normally what is considered that if a you are suspending one rope when this rope is suspended then after that you say if it is up to 30 percent of the load of the rope that the kinetic shock on that rope is maximum beyond which effect is either constant or will diminish.

So, this length of the rope is called your well that is called your critical depth or critical that means, when your suspended load is coming your 35 percent of the breaking load, then you are telling that we have reached the critical one. So, for example if you say find the critical depth while hoisting from a depth of 300 meter using a locked coil rope of factor of safety 8.

So, this critical load it will be depending on the your snap length, snap length is if you suspend a rope like this. Now, the rope will be having its some weight then the suspended load if it is more than the breaking strength then what will happen? That the rope will get torn that depth is called your snap length.

So, for example that is your the lengths of the rope the weight of which is the breaking load of the rope that is the condition for snap length, if you know the snap length then the 35 percent will be it will be easy to collect correct for this one, because a factor of safety it is the breaking strength plus that total suspended load if this factor of safety is given 8 then you can find out that is your what will be the depth or the critical depth H when this will be 8 and then this is becoming 35 percent.

So, that critical depth is nothing but this your 0.35 into W by r. So, that is W by r is nothing but that is the snap length by a factor of safety minus advantage. So, by using this formula you can find out that what will be for a given snap length that is if there the snap length will be depending on by what material the rope is made of.

If the rope is made of some different quality of still definitely the snap length will be different. So, this diameter and the material that exactly determine what will be the snap length. So, once you know that is your from the if you see this graph there is a relationship between the critical depths and the depth.

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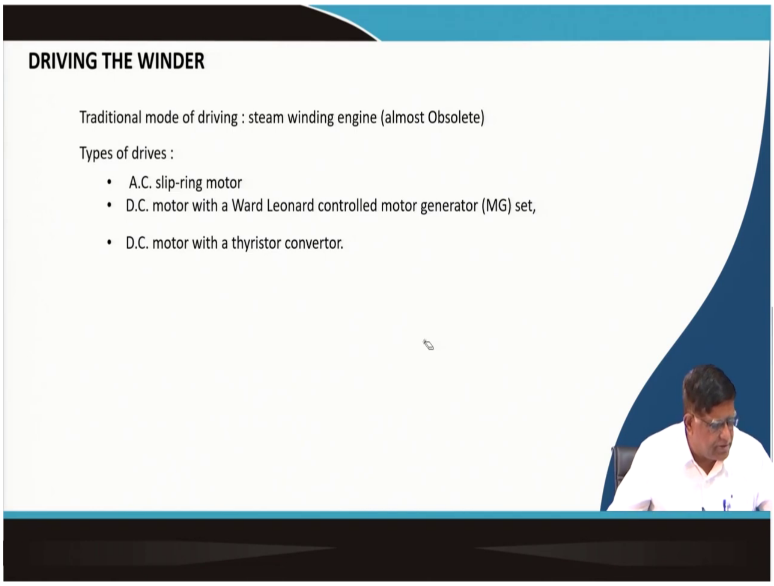

Now, you try to draw something as a you draw some graph that is showing this your what is your the depth and the critical depth and try to understand what is the behavior of. So, this is your as a learning activity please do that. Then how will you drive this winder to drive this winder you will have to normally you have this AC slip-ring motor or DC motor or there could be a DC motor with thyristor converter. Nowadays of course, that advanced the motor drive industrial drive with AC drives are now available.

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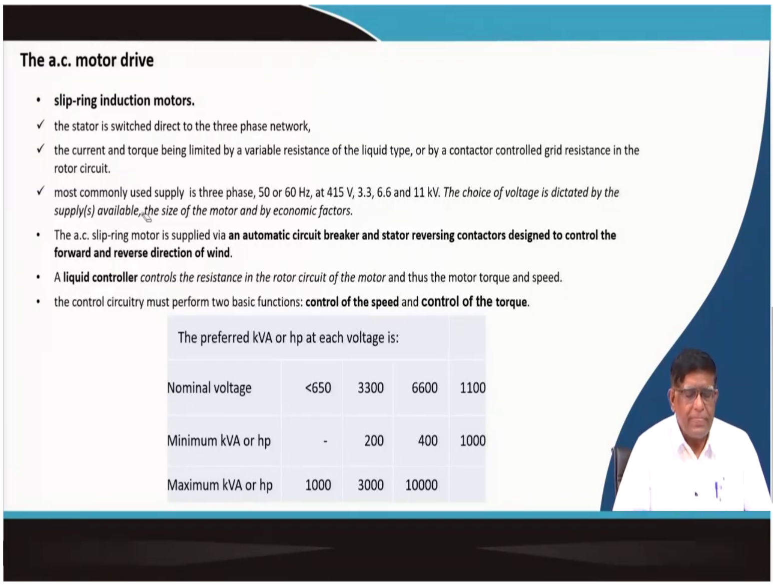

Now, that in the old time your these AC motor drives were mainly slip ring induction motors they are used and then there the supply voltage and the phase is normally your our country we get 50 Hertz this one’s up to maximum 11 kV supply is there for a very heavy winder for winding from a greater depth and also sometime for many loads.

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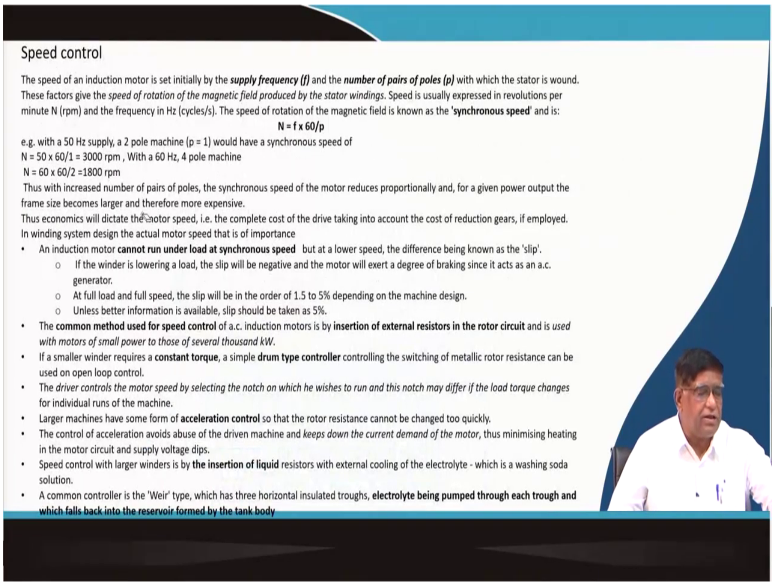

So, this another things as a speed control of such winder this speed control is also there are various things that the motor speed control in your electric engineering paper you have studied about the control of speed in AC motor and DC motors separately. If it is a DC winder DC motor type of winder you can have a smooth control, but here different mechanisms for controls were there.

But as a what is that motor speed? Motor speed depends on the frequency and the number of pair of pole. So, this main formula that is your number of pair of pole and then the frequency that determines at what speed the motor will be running these are fixed. So, you can find out if it is a your 2 pole machine then your P value is 1 then with the frequency in our country is 50. So, you can find out that N will be your 3000 rpm.

Now, if you are making as a 4 pole then what will happen? In a 4 pole machine the machine speed can be reduced to 1800 rpm and from there that means, you can do by two methods one by the voltage control or by the frequency control your speed can be in industrial motor can be changed.

And then earlier to do these things with a voltage control they are exactly you are in the DC motor in the shunt you are adding a resistance and then capacitance by that you were controlling the DC motors speed. But, nowadays we have got advanced this speed control systems, but at the same time there were some of this how will you do the acceleration control and that is your there were some insertion of liquid resistors by that also that means, giving the resistance more that means, the voltage will be dropping and then if the voltage drop your speed will be reduced those mechanisms were there.

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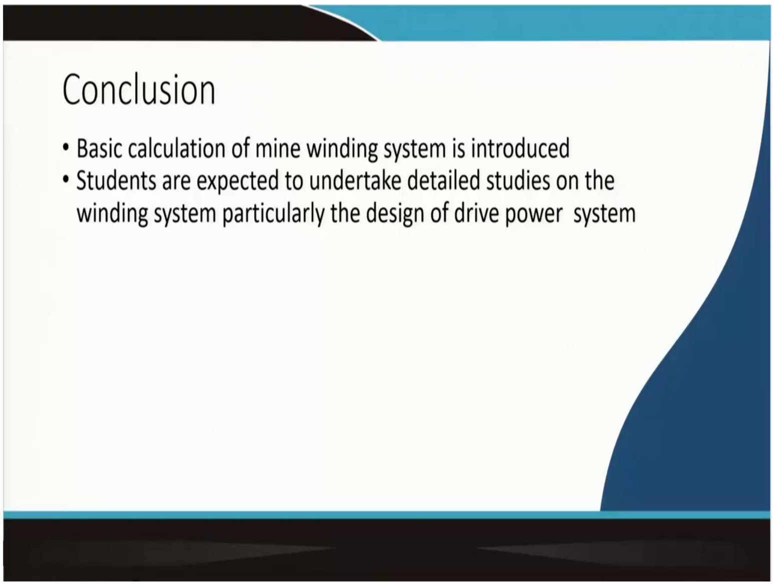

So, this part is you can see those circuits if it is if you are interested that a little bit more can be going over there, but say there are many calculations winder design calculations are there.

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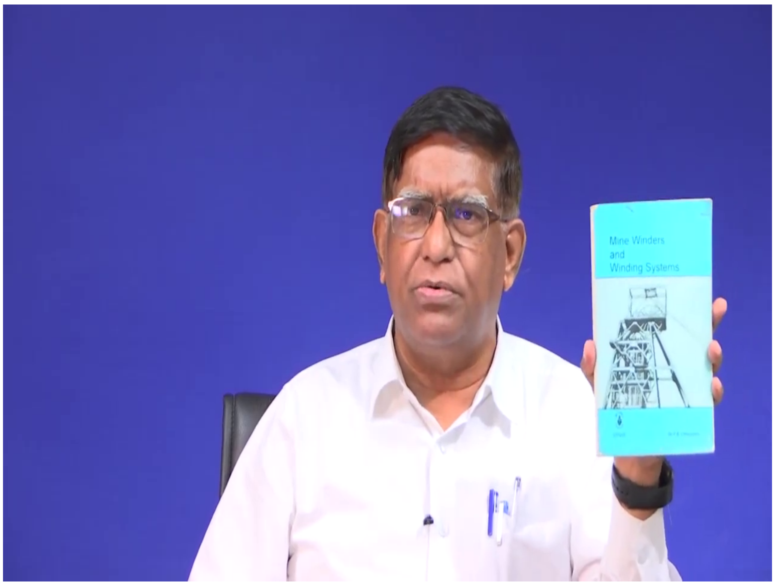

I request you this book I have referred as a this book is by Dr. PK Chakraborty's book that is published by CMPDI when it used to do a lot of winder design in the 70s in the 80s- 90s number of mine design were done by their methodology which have been discussed in this book by Dr. PK Chakraborty.

This book was published in the 1999 or so in CMPDI. Please have this book and what I request is as I told you earlier that methodology can be converted to a simple that your management tool for maintenance and then all the necessary calculations can be carried out.

So, with this I think that you have got the basic introductions of mining machinery, we conclude our general discussions on different types of machinery and then as I the next class is about this low profile dumper which is a another transporting means in underground mines.

But, as such we have done through our this journey with this subject that falling to you to give a basic understanding of this subject and then what are the total scenario of it, but there are a lot of things to be done and then lot of things to be learned this is only I have given you a overall concept of what is mining machinery. And I hope that you will be taking up individual learning exercise for doing several problem.

In my next class I will briefly introduce in another 2 hours or 3 hours of class about the whole thing of maintenance engineering. Because there are two aspects we are not manufacturing many machines in our country, but we must maintain them for their high quality, high reliability and safety that how to maintain that. So, basic principles of maintenance engineering and some of the very simple examples I may give it from whatever is possible in the coming 2-3 class.

But I wish that the books and the things which have been referred and then some of the learning activities which has been suggested you please go through that. And you can send your email ID and then you can join and keep yourself registered in my mining machinery learning module pages. So, you are always welcome. If you have got any questions any doubt do not forget to note and refer to me.

Thank you very much.