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NPTEL ONLINE CERTIFICATION COURSE

Course
On

Spur and Helical Gear Cutting

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Lecture 17: Gear Hobbing - III

Welcome viewers to the 17th lecture of the open online course spur and helical gear cutting okay.

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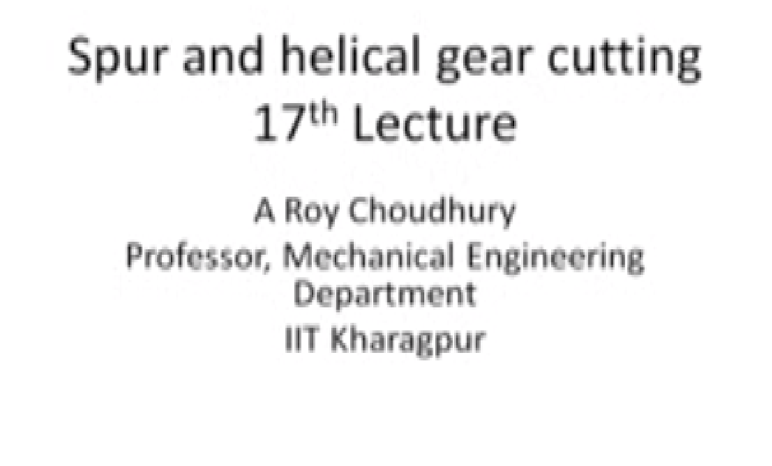

So last day when we stopped at the end of the 16th lecture we were dealing with the you know the calculations of the gearbox ratios for the gear hopping machine in connection with the solution of a numerical problem, so let us move right away to the problem.

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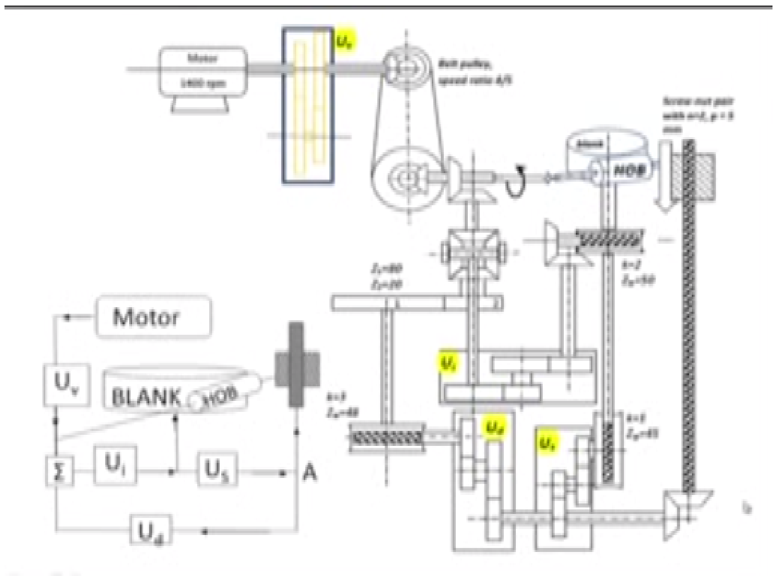

This was the figure that we were dealing with this was these were the positions of the gearboxes which we have checked against this figure and they all have matched and we have four gearboxes to solve the speed gearbox see we the feed gear box US the index gearbox UI and the lead change gearbox our differential gear box UD so just to pick up the threads this is the work piece this is the hob this is the motor this is you know the flow of power is being shown through the different mechanical elements this is the differential which is adding up two inputs.

To produce one single output the differential is shown here is a summation symbol it is adding up the input from UD the lead change gear box and the input from the motor side okay and the addition is being passed through UI and finally being given to the blank it is also passed downstream through the regular other main mechanical elements, so this was the setup we have already had a look at it.

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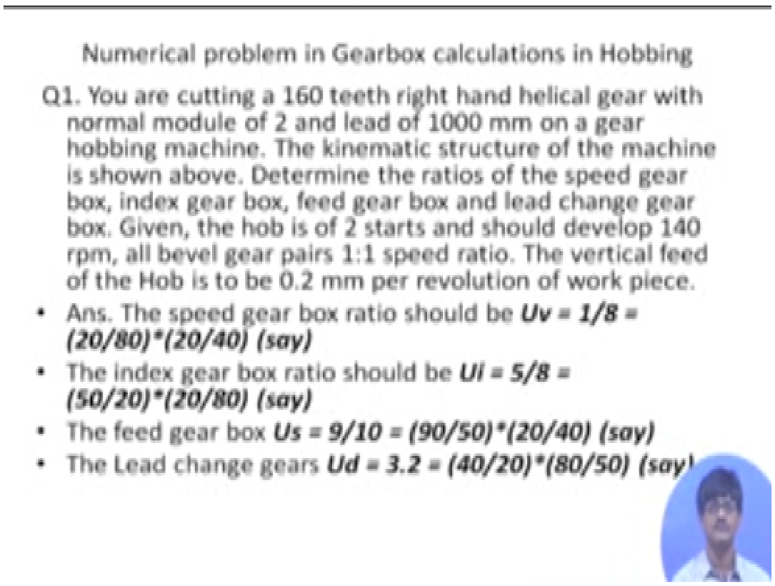

Now the next one the problem you are cutting a 160 teeth right hand helical gear with normal module of 2 and lead of thousand millimeters on an gear hobbing machine so what is the information that we have 160 teeth that is okay, normal module is 2 and lead is thousand millimeters so if you look at this figure it looks like this.

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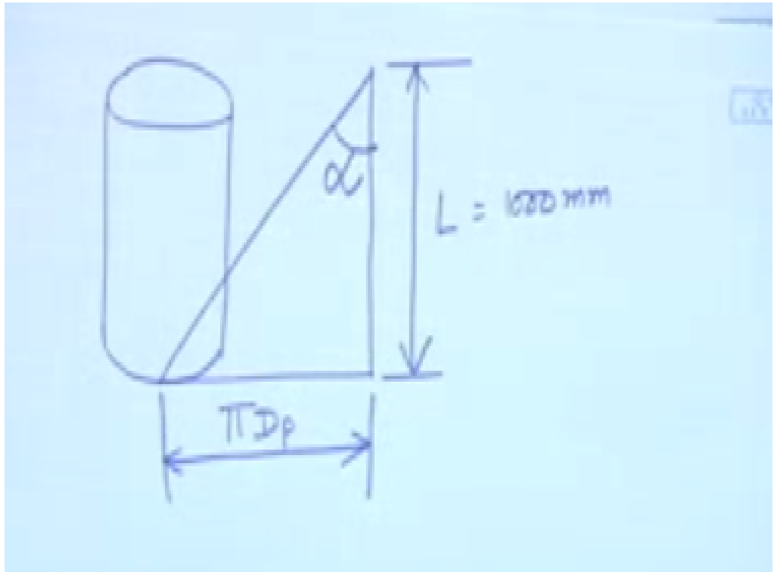

If you unroll one tooth this is the lead equal to thousand millimeters this is the circumference equal to ΠD_P mind you here it will be equal to M normal module into Z number of teeth divided by Cos α where α is the helix angle, helix angle okay.

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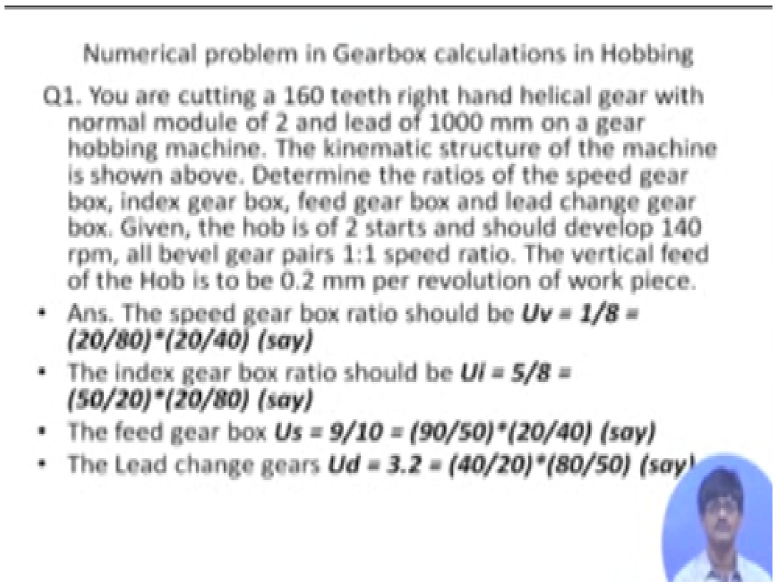

So coming back we have did we have further into the question determine the ratios of the speed gearbox index gearbox feed gearbox of the lead change gearbox that is good, given the hob is of two stars and should develop 140 rpm all bevel gears gear pairs one is to one speed ratio etc okay so let us set up UV once we are discussing about the value of UV let us take a quick peek back at the figure.

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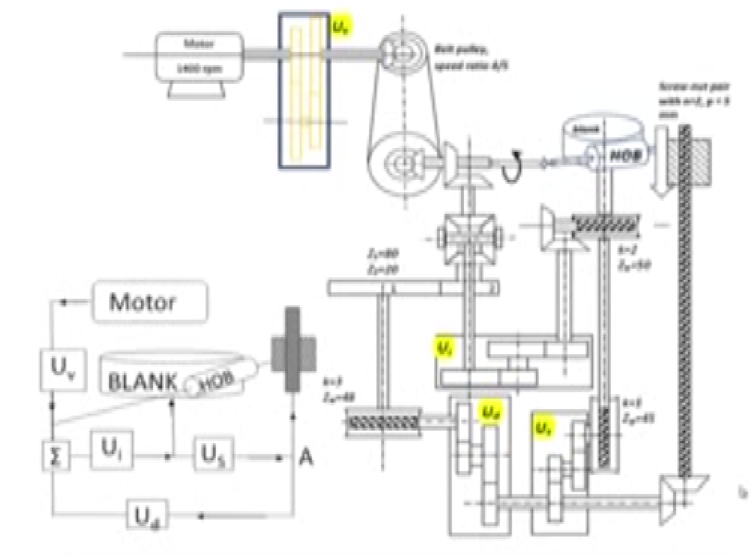

So we have the motor 1400 rpm this will be multiplied directly with UV which has to be found out this is multiplied by you know here it passes through a bevel gear pair and we know that the death speed ratio is 1:1 so we do need not bother about it after that comes a belt pulley with speed ratio 4 : 5 so we will take it as output rpm/ input rpm okay so 4:5 multiplied so 1400 x UV x 4 : 5 okay multiplied by 1 :1 etc. How rpm, 140 so let us write it down.

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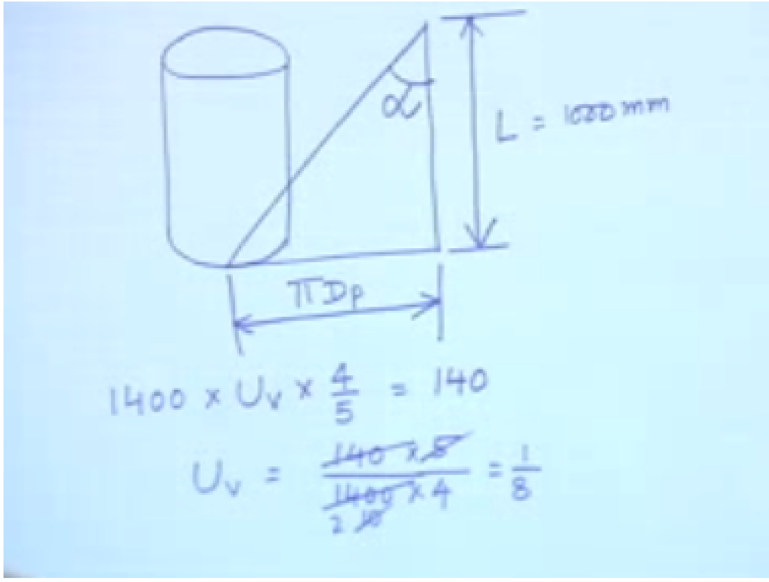

1400 x UV x belt pulley 4 that's it, after that there is no other member affecting the RPM so this must be equal to 140 rpm as given in the problem. Let us find out what UV comes out to be UV comes out to be 140/1400 x 5/4 equal to this, this we have a 10 here this, this we have a 2 here so it is 1/8. UV = 1/8 okay.

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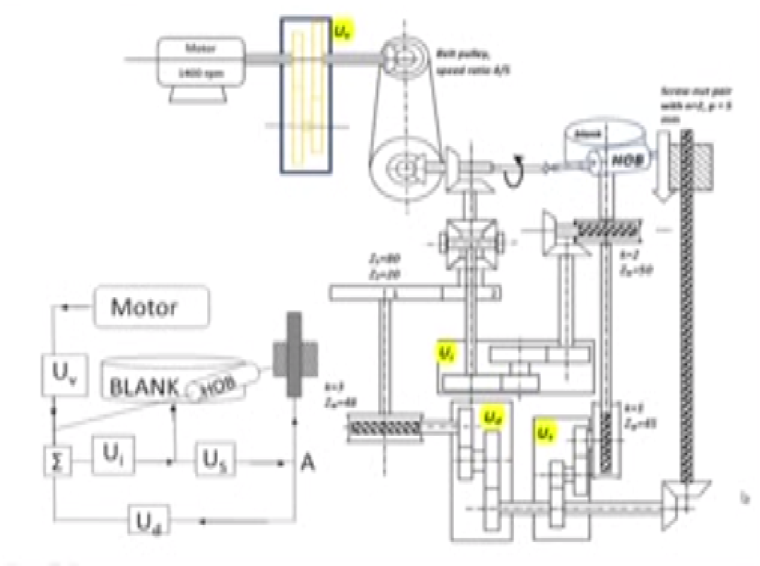

Next so UV is matching I have also included in the, you know PPT the solution okay. So if you by chance miss anything in the lecture you can always refer to a PDF of the, you know lectures which will be uploaded and you can be a brisk of the solution. Index gear box ratio let us find out the index gear box ratio and for that once again we move onto this one index gearbox ratio that is the index key above you here it is where is it here it is so index gearbox ratio if we remember it determines the number of keys to be cut.

And it determines in order to do that it determines the speed ratio of the blank and the hob what is the speed ratio of the blank of the hob if we consider them to be you know once again worm and worm gear pair in that case we have their speed ratio should be K/Z where K is the number of starts on the hob and Z is the number of teeth to be cut so here the number of teeth to be cut is 160 and the number of starts on the hob is equal to 2.

So the speed ratio should be 2/ 160 = 1/80 so let us see how UI is managing that so if you look at this from the schematic view first of all we can say that if the hob is rotating okay if the hob is rotating in that case for every rotation of the hob the blank should you know we go all this way and ultimately land up on the blank the blank should be having a speed of 1/80 rpm okay, once we you know once we decide on that let us go back to the so just one more sentence regarding the schematic view.

So we will be passing through you know hob blank in 1 rpm and then we pass through this differential okay and we have to decide what sort of influence this differential will have on the rpm, next we pass through UI and after that we go on to the black. So let us look at the figure once again hob rpm, so if the hop is rotating once this one rotates one is to one and we arrive at the differential this is the differential.

Now what happens at the differential suppose I am rotating this particular gear if I am rotating this particular gear in that case for the time being we consider that the input from the lead change gears okay, the input from the lead change gears UD this input is locked zero rpm okay it is not moving so we understand that the gear marked two the bevel gear connected with gear 2 it is having 0 rpm it is fixed in space if it is fixed it does not rotate in that case.

This one will be rotating and imparting some rotation onto these two okay these two and how will they rotate they will be rotating and half the RPM of this one why so?

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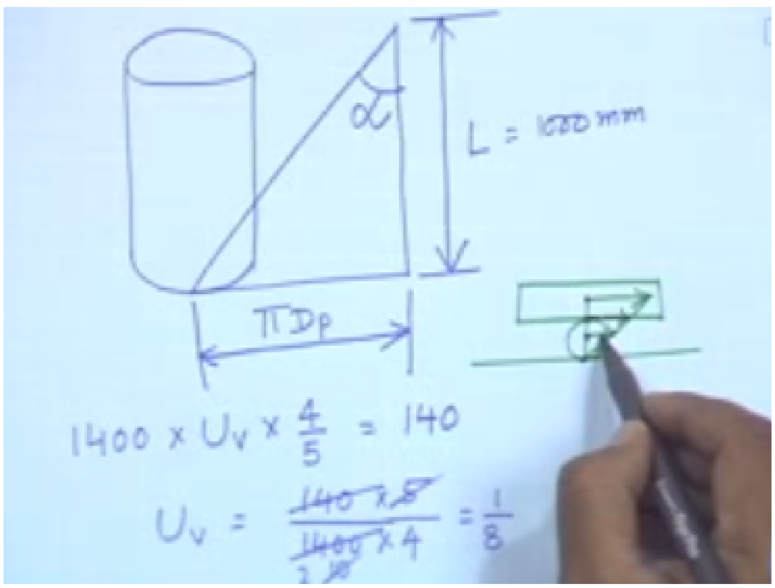

Because if you look at this they have a relation of this type roughly remember how heavy stones I mean heavy pieces of stone they were moved up a during you know during the time pyramids and other things are built they were moved up on logs okay so the this particular velocity is going to impart half its velocity at this point okay, this velocity rather here this velocity is going to be half this one sorry the figure is too small let me select a new piece of paper right.

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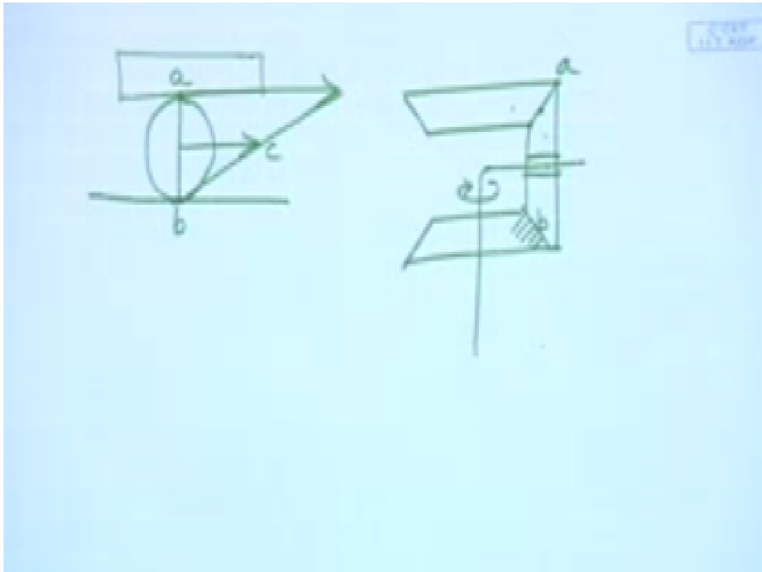

If you have something a steady member on that there is a rotating member and this tangential velocity is shared with another member they will have a velocity relation of this type this Center Point will have half the velocity of this one and the same thing is happening here this one as we discussed is not moving it is fixed on that this wheel is rotating and this one is having same rpm as I mean so the same tangential velocity this side the paper same tangential velocity.

The case which is existing here so a corresponds to a, b corresponds to b okay and C corresponds to C this rotation if you have an arm this rotation so this rotation is going to be half of this one okay once we accept that okay once we accept that then we understand that there is going to be a ratio of 1/2 multiplied with the input rotation coming from the hob okay.

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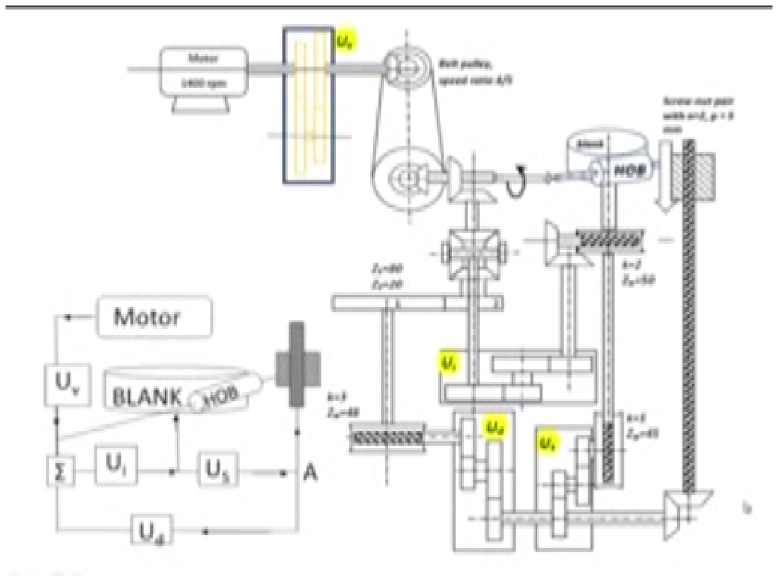

Now this can also be derived by one equation called the helix equation okay we can have a look at that when we have some spare time from these lectures, so once we have a ratio of half introduced so we have hob rotation multiplied by half coming to this particular rotation x UI is equal to you know k/z. 2/50 = 1/8 okay let us see let us see the calculations now.

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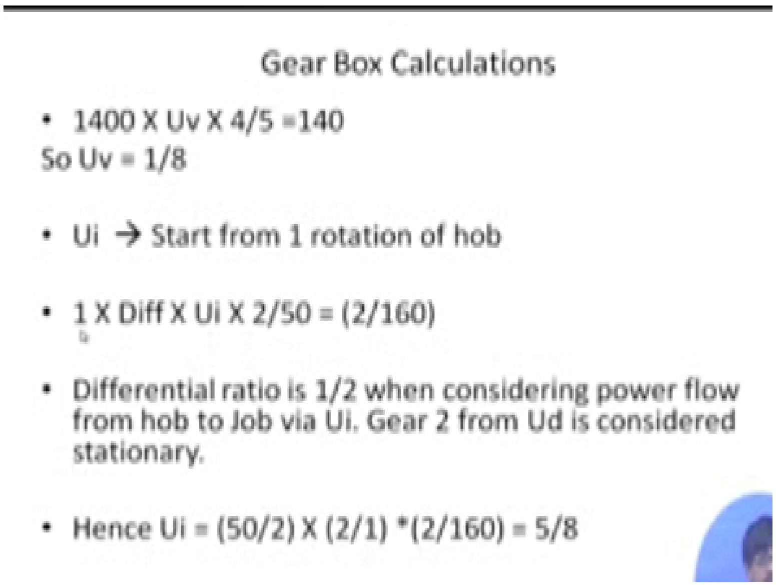

Right see one rotation we start here one rotation of the hob with multiplied by the differential ratio multiplied by UI x 2/ 50 = 1/80 and differential ratio is being taken as ½ okay, so UI comes out from this calculation to be you know 2/60 is there which means 1/80 and 2/50 is here sorry 2/160 is 1/80 and 2/50 goes there as 50/2 which means 25. So 25 multiplied by 1/80, so 25/80 and this half goes to the other side 25/40.

So if there is 25/ 40 it will give you 5/8 so UI comes out to be 5/8 as per our calculations so UI have been solved UV has been solved already.

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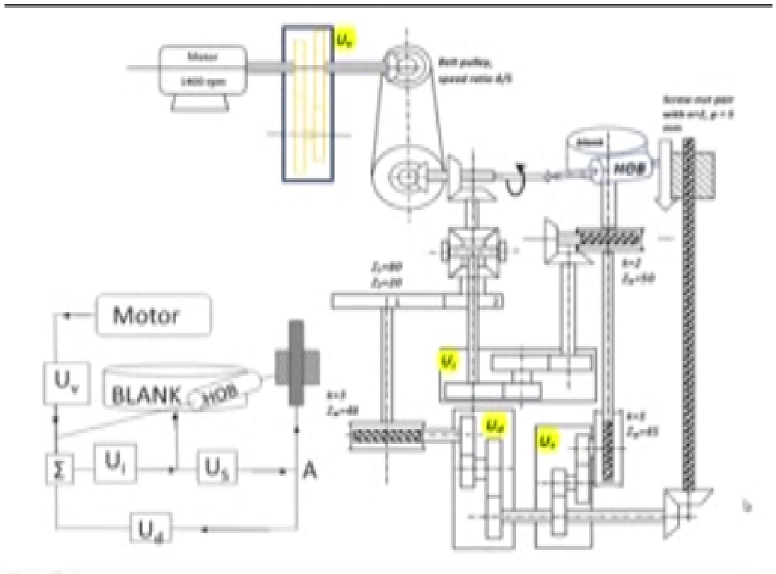

And therefore we move on to now the feed gear box we will determine how feed gear box is decided let us see where feed gear box is situated the feed gear box is situated here and the feed gear box we can notice is here, how is the feed gear box you know influencing the operation of the machine we say that is the hob is moving down too fast in that case it creates a problem that the surface which is left it is going to be too rough let me draw a figure and show you.

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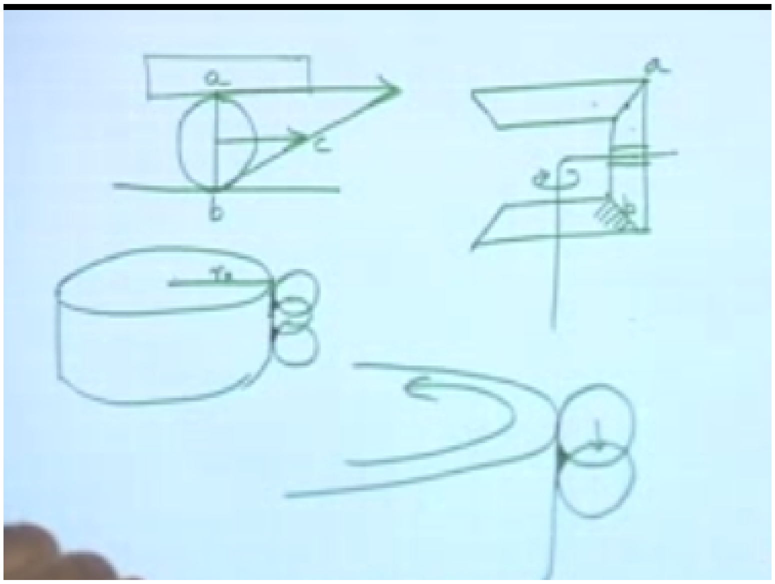

If this is the blank and this be the you know idealized position of the hob there is only a point-to-point contact so after every rotation say this particular meridional position this radial position we call as RX so it is going to come back to RX after every rotation one rotation it is here second rotation is here third rotation is here so it leaves behind these small scallops of material how does it look like in a blown-up figure it looks like this.

This is one position so this is going on rotating and this is descending so it will reach this position say after one full rotation of the work piece purpose rotates and will leave behind this part uncut and therefore this is going to define a roughness on the teeth or on the other profile okay so if that happens we would like to set a particular feed which will give us acceptable roughness if we want an acceptable roughness in that case okay.

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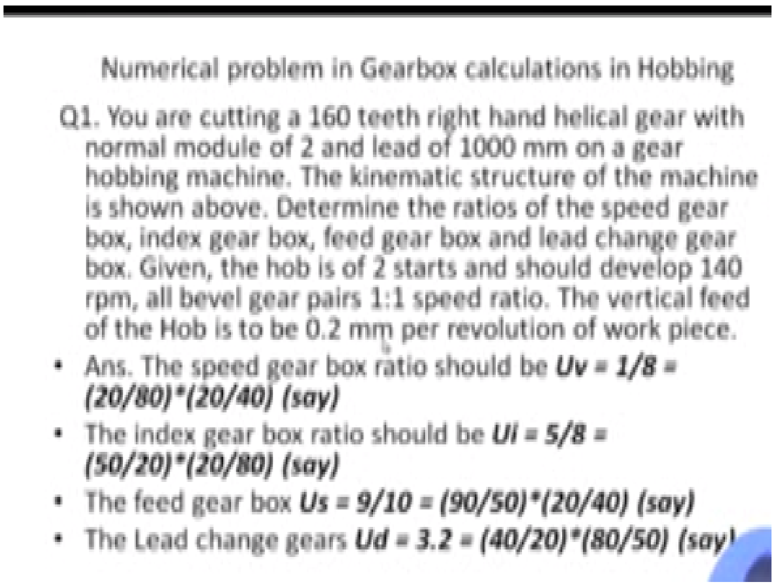

In that case let us see what is what has been designated in the problem, the vertical feed of the hog okay it is written here sorry the vertical feed of the hob is to be 0.2 millimeters per revolution of work piece so that is now understood that per revolution if the work piece rotates once the hob has to come down by 0.2 millimeters by that particular time.

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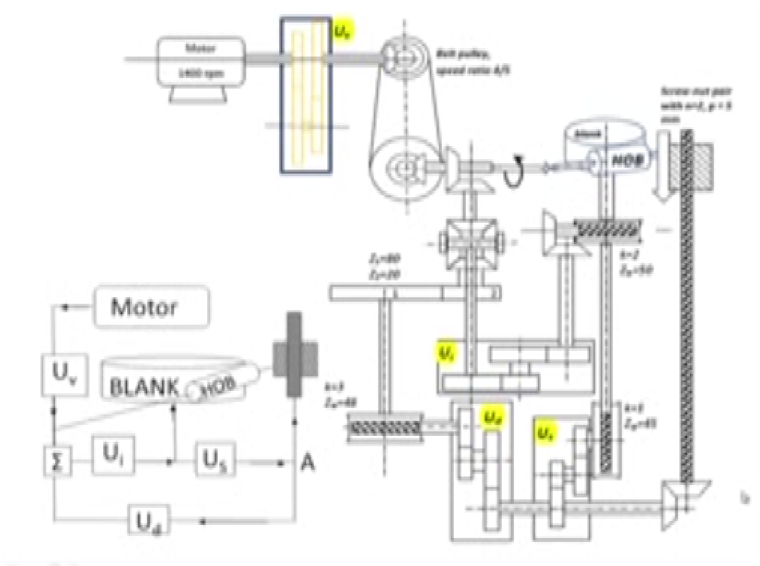

Let us go back here and let us see how this is implemented first of all how is the hob coming down well just as it is rotating it is also attached to this nut this nut is attached to the hob so that if the nut goes down the hob goes down as well so who is making the nut move down this particular screw vertical screw which can be seen here this is rotating and it is bringing the nut you know further and further down.

Now if the nut is really you know moving down why does not it rotate with the screw because we are restricting that the screw is restricted from translation and the nut is restricted from rotation and so therefore if the screw rotates we have the nut moving down how much does it move down it moves down by it is supposed to move down by 0.2 millimeters by the time the work piece rotates once.

So we say that okay let us let us move this way say we have 0.2 millimeters of motion let us work it out this way or let us say instead of starting from the this side we can start from the blank hole so there is absolutely no harm, we say that I will start with one rotation of the blank move down through all the mechanisms and finally arrive at this at this nut and I will assign that particular value which I derive equal to 0.2 so in that case what do we have to do we have to if you look at the schematic diagram you have to move through this channel.

Blank rotation US and then finally the lead screw and then the nut and just this particular path will give a help us in you know defining US, so blank rotation is one so me we move right down so we are moving down why did not we take this bifurcation because it has nothing to do with the vertical motion vertical motion is defined you know right down to this position okay we come across a worm and worm here.

And therefore we have one rotation multiplied by K/Z which means 1/ 45 so one rotation of blank multiplied by 1/45 x US out we come here into 1:1 must be equal to the number of rotations of this read through and per rotation it moves by screw nut pair is given screw nut pair they have n = 2 = P= 5 which means the number of starts equal to 2 and pitch equal to 5 which means 4rotation it moves by 10 millimeters lead is equal to number of stars and multiplied by the pitch P, L = NP per rotation it moves by L so the rotation of the screw will be multiplied by L to give us to give us the final movement of the nut which is equal to 0.2 let us write it down here.

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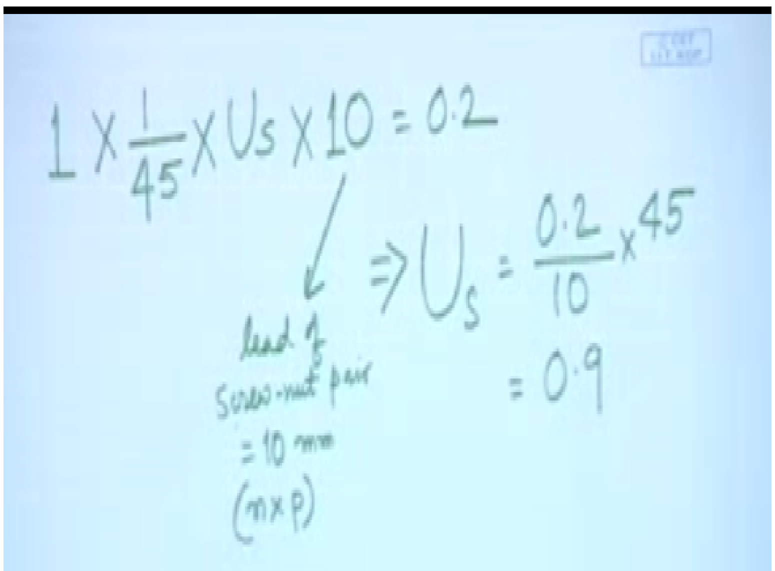

One rotation of the work piece multiplied by 1/45 which is the form and worm gear pair x US because we are now moving through US multiplied by L lead of the lead screw nut pair 10, all right lead screw not very crew ten millimeters which is really equal to number starts in to pitch, L = NP so this should be equal to 0.2 and therefore we have US = 0.2/ 10 x 45 and what does it give us this must be 90 okay. This must be 90 point are we correct 0.9, 4.5 x 0.2, 0.9 US should be equal to 0.9 okay let us see yeah.

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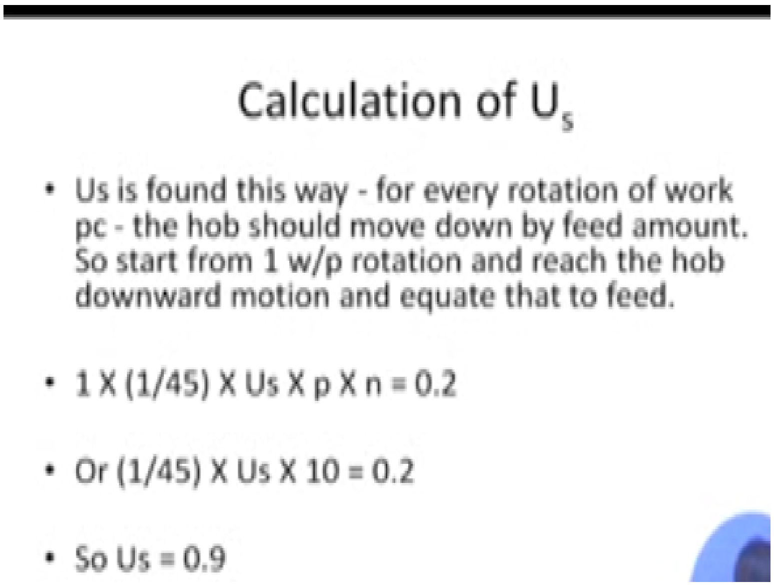

US = 0.9 right therefore we arrive at the calculation of I mean arrive at the answer of UV, UI and US and last fall we have the lead change gears let us look at the lead change gears.

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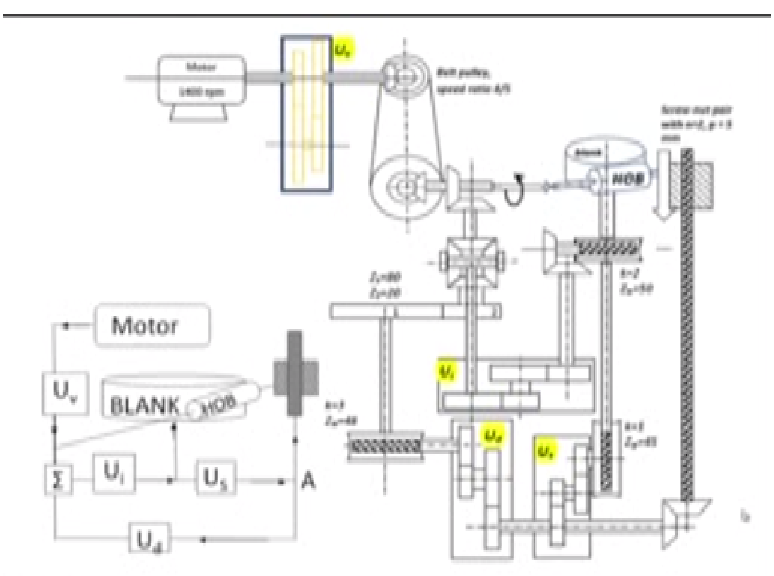

So for that one thing in the figure where are the lead change gears the lead change gears are US coming here if you if you follow me from the point it is a bifurcation on one side we are serving the screw on the other side we are serving the lead change gears normally when you are cutting spur gears they do not take part in the cutting action but now they are going to rotate and they are going to get added up to the rpm which is imparted by virtue of hob rotation from the other input side.

Two inputs getting added up and forming the final rotation of the blank now the question is how much should I rotate the blank by this particular input from the other side of the input I have already calculated I mean we have already calculated the amount of which has to be given to the blank and accordingly we have decided upon the value of UI but from this side an additional amount of rotation will be provided which will take care of the fact that helical cut will be imparted. So for that I will just once again comeback to the figure that we had discussed the last day.

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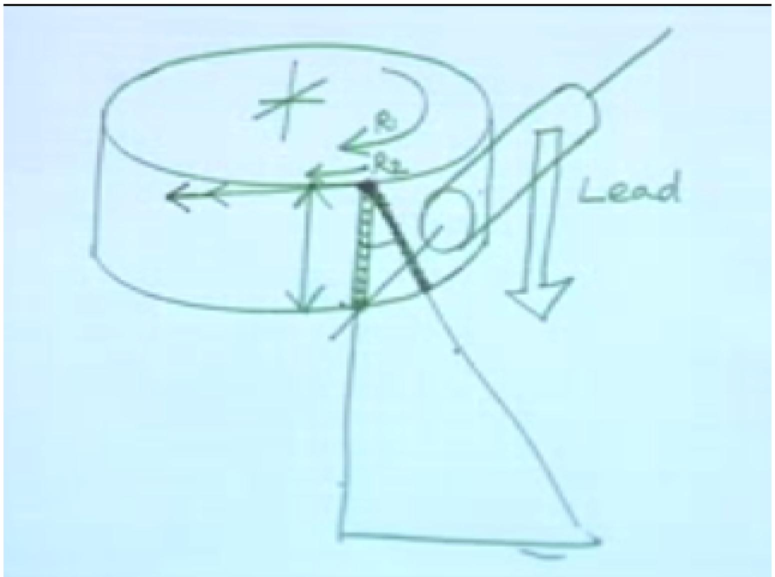

This being the job we can avoid all sorts of you know very complex complicated calculations by this particular statement that whatever be the rotation ratio of the work piece and the cutter this is the cutter the hob whatever their rotational ratio that is creating synchronization that means if one cut takes place another cut is going to take place later on and along this particular line when the job is going down exactly one cut is going to take place this way.

This is accepted over and above that if I suddenly add if I suddenly add yet another rotation so this was rotation one r1 and this is r2 if I add an extra rotation in that case what will happen is this will get staggered either to this side or to that side depending upon this extra rotation if I add this extra rotation so that it adds up this will move faster and therefore this will be you know lagging behind okay.

Let us see this one once again this one I am sorry this is moving at a particular rate so that it is synchronized now if this body moves a little extra amount therefore what will happen is this particular part which was to get cut it comes here it does not get cut okay and therefore there will be a cut of this type the body is getting a head so the cut is falling to some place which is you know lagging behind so the cut will take place this way how do we calculate how to make this cut at the particular angle that we want.

For this we say that whatever is the initial rotation that has been taken care of butter by the other side of the movement but this particular input will be such that by the time I get from this point to this point I will be rotating the job one extra turn so this is coming down there is no problem with this, this is coming down and due to the first rotation this is exactly coming down along this line so if I rotate some a bit extra amount if I rotate a bit of extra amount.

So that by the time it has moved down by the lead this extra rotation is exactly one rotation I will find that it will have these lines along the helix angle all right, so our relation will be if this one goes down by the lead amount lead of the helix which is given to a thousand by the time the hog moves down by a thousand millimeters an extra rotation will be provided okay you might say but this is not going all around by Π D no but if you if you now consider this way this relation will be maintained this will be thousand okay this will be thousand and this will be Π D.

Because we have related them this way by the time a lead amount of movement takes place this is only the width of the gear this is not lead this might be hardly say how much one inch that mean s25 millimeters 30 millimeters like that and the lead is thousand millimeters so we are relating them this way by the time you go down thousand the full rotation is achieved. So by the time you go down by the width of the gear a certain amount will be achieved but they will be in the same ratio therefore this helix angle will be maintained so let us see how this relation is maintained by the time the hob goes down by lead extra rotation takes place by one full rotation.

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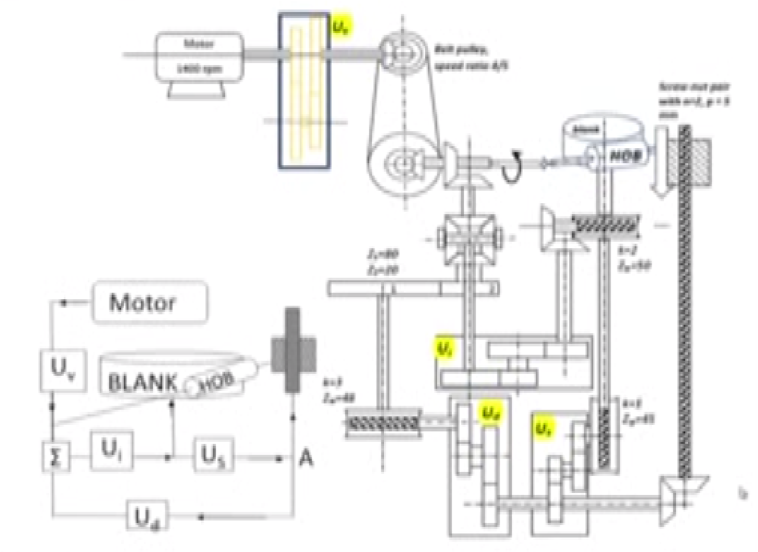

So with this in mind let us look at the schematic figure now so we will say that I will achieve a thousand millimeters that is lead amount of motion in this particular knob for that I will have a certain number of rotations of this screw with these many rotations I enter UD that means the lead change gears and from the lead change gears I go to the differential I calculate whatever ratio differential offers me when the other output is off and this input is on and I pass through UI once again.

And the rotations that the blank should have for this case is one rotation, so coming to the figure now actual figure with details okay here if you look at this one this goes down by lead which is thousand how many rotations of the screw should take place for those thousand millimeter you know lead movement vertical movement definitely thousand divided by ten millimeters so we can say that the work piece lead by the machine lead which is very popularly used work piece lead thousand divided by the machine lead.

Which means the screw which is belonging to the machine it has its lead as ten so thousand by ten must be the number of rotations of this lead screw that is good 1000/10 is 100 rotations, so 100 rotations per minute it is now input to the do not stop here this is not stopping it this shaft goes right through to you d so hundred rotations x UD and then comes a worm in worm gear so it is 3/48 this enters Z 1 / Z 2 = 80 / 20 and we arrive at the doors of the differential.

How will the differential act here, here the other side is now locked the other side does not rotate okay while the other side is locked this one rotates and once again a ratio of 1/2 will be multiplied so when this ratio of 1/2 is multiplied we have multiplied by 1/2 enter UI once again, so entered UI once again, now from the other side of the differential so x UI 1: 1, 2/50 is equal to one rotation of the blank okay. Let us write it down as per this relation.

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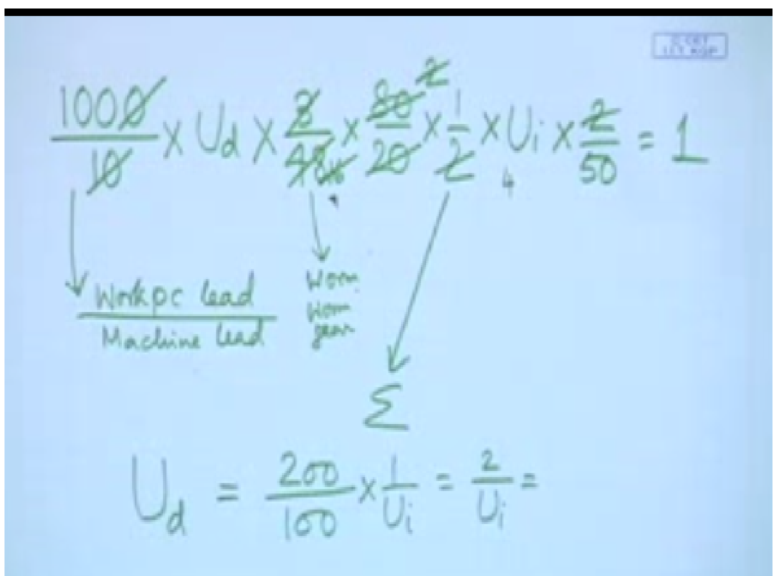

So we write machine lead by sorry work piece lead by machine lead so we write here work piece lead by machine lead so this gives me those hundred rotations per minute and we enter UD multiply UD here right away in some books they take the direction of motion low of power to be the opposite and they will arrive at UD = 1/UD of our calculation let us not worry about that so x UD x 3/48 as we saw in the figure multiplied by Z 1/Z 2 = 80/20 x ½ contributed by the differential so this is coming from the differential this is coming from worm, worm gear.

This coming from the spur gear pair so after we enter the differential we multiply UI once again we are coming going through UI once again after we come out of UI you will find that we enter 2 /50 another worm and worm gear and this should be equal to 1, so let us have a solution of UD in this manner so this will cut off this cancels with 20 and 2 equal to 2 that is good 3/ 48 cancels by 16 this one cancels out this 0.

So this 16 that we have here will cancel out with these two tools and we will have a 4, so 4 x 50, 4 x 50 is 200 so if we put a 200 here and this hundred goes down have you left of everything anything yes UI, UI is there multiplied by UI so it is 2/UI now how much is that.

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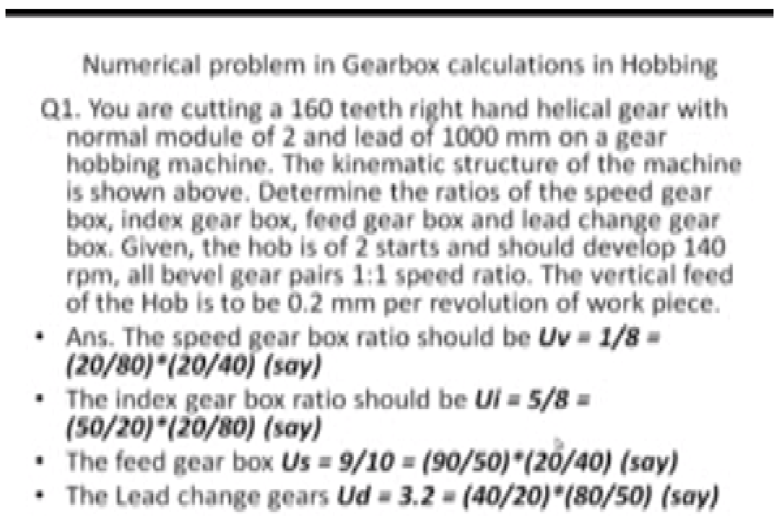

Let us see how much we UI, UI = 5/ 8.

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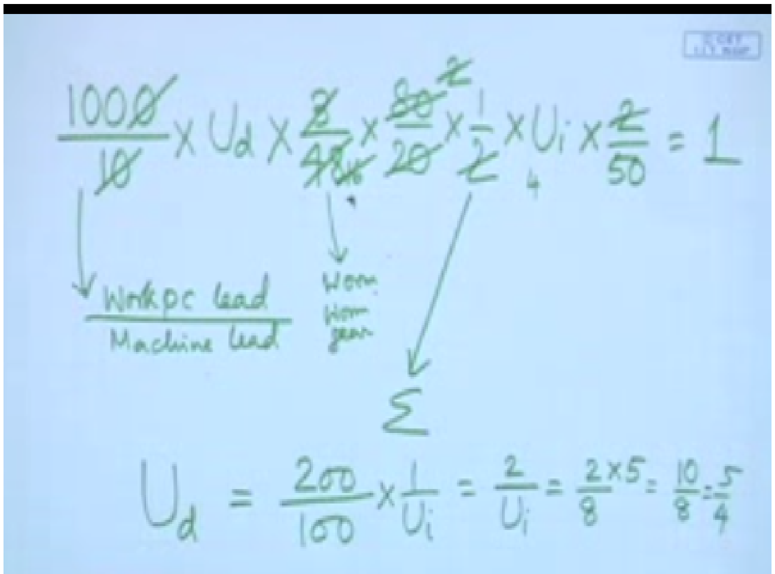

So we write 2/ 8 x 5this is equal to 10/ 8 which is 5/ 4.

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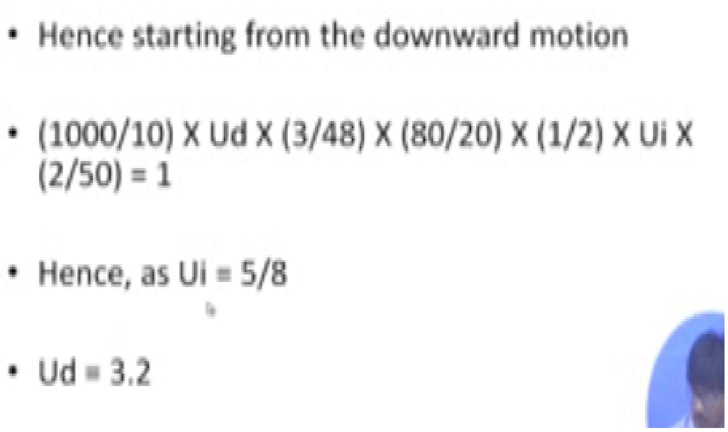

Let us see thousand by 10 that is good 3/48 that is good 80/20 okay half right into UI x 2/50 = 1 and UI has been put to be 5/8 did oh right.

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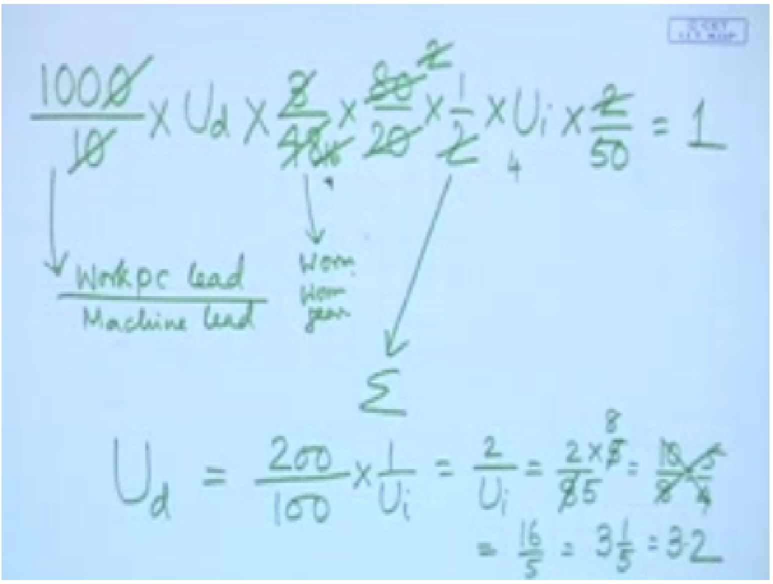

Here we have made a mistake it should be 5 at the bottom and 8 at the top so please I am actually sorry for this please make the change so this is 16/5, 16/5 is how much 3 and 1/5 which means equal to 3.2 so this way we find out the you know ratio of UD and come to the end of the numerical example.

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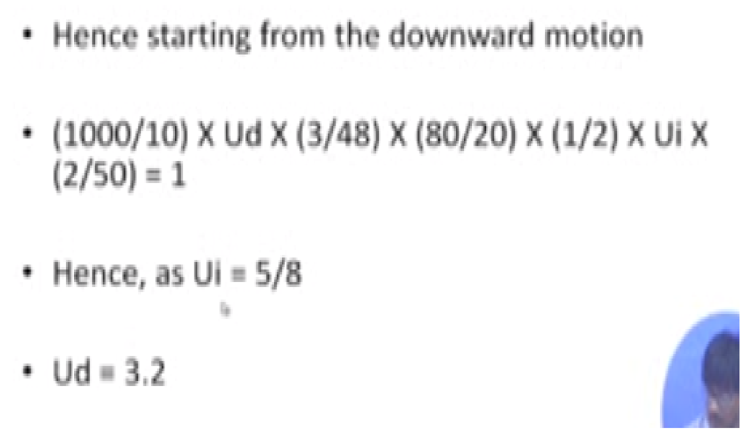

And therefore we will continue the discussion on you know vertically gear hobby in the next lecture, thank you very much.