NPTEL

NPTEL ONLINE CERTIFICATION COURSE

Course
on

Spur and Helical Gear Cutting

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Lecture 11: Gear Shaping – I

Welcome viewers to the 13^{th} lecture of our spur and helical gear cutting.

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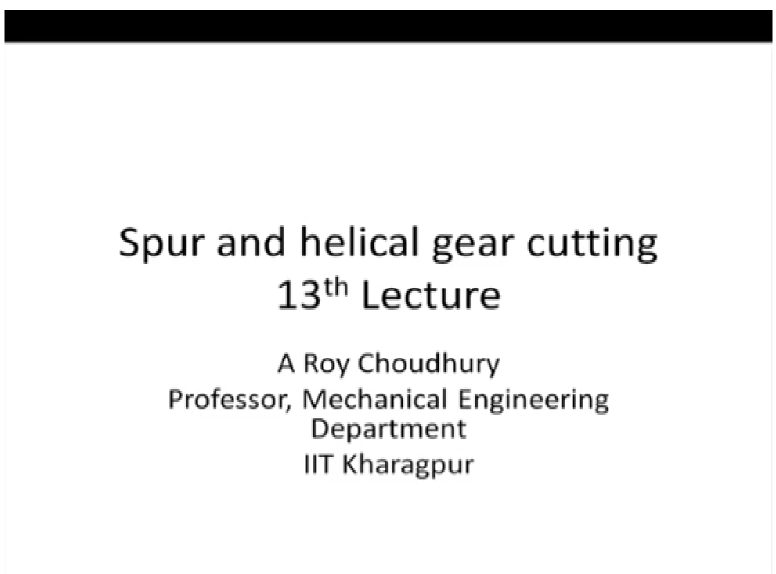

So today we are well poised to start you know some discussions on gear shaping machines.

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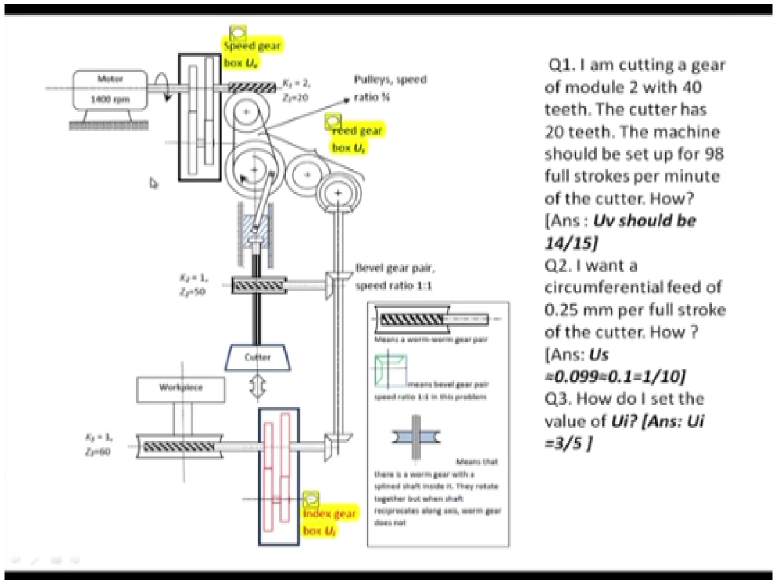

So basically we will discuss about gear shaping machine and pick up numerical problem and I will also post some supplementary material in which you can see actually a gear shaping\g machine in action and we will also solve some multiple choice questions okay. So let us start withdrawing though after you know aa first side this might me quite formidable actually the quite simple.

In what way for example in all such drawings involving a large number of machine elements, let us first identify the prime over this the prime over the motor the motor is rotating at 1400 rpm and after that we have some regular in a machine parts, for example let see se from her we have a new gear box here. As some of pyire knowledge we can say this must be the speed gear box so here if it is in speed gear box U.

So inside here are some gears you might say what are the value I mean what are the numbers of pw these gears. I will say it will vary from case to case. If you are you know a playing the particular condition that I want particular condition or this particular number from strokes per minutes that will decide this particular gear box setting so at this moment if having no particular numbers of the sign to the respective gears.

After that at the output side of the gear box Uv, I have this particular machine elements connected to the disk shaper body. One of this will look a threaded element okay. This is a threaded element and this value of t1 =2 and z1= 20 this gives you the end but it must be a warm in warm gear pair. So we have a warm and a warm gear pair just beyond the speed gear box okay.

That is fine what is the warm and warm gear pair do it is having a number of starts equal to 2 and number of teeth on the verb is perform here x=20. Which is the warm gear this is the warm gear okay? This one the warm gear, so it will undergo rotation coaxial with the warm gear we have sort of pinion or sorry not a pinion there a pulley attached okay. This one is a pulley and it has same rotations per minute as that to warm here.

With this pulley we have a belt and the belt is going all around a larger pulley at this particular position. So we will effectively have rotation of this larger pulley due to this belt connection with the smaller pulley. Once this pulley is rotating there is connecting rod connected with t you know reciprocating block this one this slicer okay. The slicer slice in these guides ways 2 and 4 and as we can well understand this rotation causes reciprocation of this block.

Once this is reciprocating this shaft we can end color okay. Embedded inside this block will have to move I mean up and down. So this one also move up and down and it is slain shaft. What is a slain shaft? And it is slain shaft, what is a slain shaft? A slain shaft is that which has you know just like gear it has teeth cut on okay. In cross section you find like this gear you have some teeth.

What is the purpose? The purpose on the slain shaft is that while it is moving up and down it can also supper rotation by member connected with teeth on we will see an example both has an drawing and also has an active you know working member in a video recorded of the process. So we have come down up to this point pulley. Pulley connecting rod and so the this pulley, this arm is acting as a crane.

So crane connecting rod sliding block okay and then slain shaft. At this moment the slain haft is not been given any rotation it simply moving to in flow. It reciprocating this reciprocation and the end of the reciprocation they are the cutter. The cutter is represented by tropism but up till now we have noticed that we have referred to the cutter as just anural here a perfectly made gear then why does it have this trapezoidal shape.

At least if it had been you know circular in shape that is if it has been represented by a perfect cylinder. It should have come out the rectangle just like the work is the access line but we actually give some relief angle or clearance angle or clearance angle towards the back of the cutter so that while that machining its surface does not you know this surface does not interfere with the finished surface formed on the work place.

As it goes down it removes material by this side a way surface and the clearance of it I relief away okay. This surface is relieved the flunk of the cutting teeth that is relieve away from the finish surface. So that there is no unnecessary rubbing, so we unlock the wings that the cutter is capable of moving up and down. Due to all these you know belts pulleys and gearings bearings all these things ultimately make the cutter move up and down.

What are the other connections let us have a quick look at that; coaxial with the larger pulley if you look at the top we are having the gear. This gear is connected in the number of gears an it makes something about gear box. Do not exactly show in a proper rectangle I mean proper box. This serves as the speed gear box. So we basically have a bifurcation here. So just after this speed gear box is a bifurcation one side go for reciprocating.

The cutter up down and the other side goals and ultimately this one connects up with the bevel gear okay. There is a bevel gear pair which makes ultimately this shaft rotate this vertical shaft long vertical shaft. What is it doing it is having another bifurcation power flows out here and plop out flows out in the form of rotations and let us take this one so to this particular bevel gear pair we are having rotation of the shaft.

And now you well conversion with this shape this must be another verb. And a warm gear what is the warm gear is doing? Exactly as we you know a previously came across its making the slain shaft rotate. But when the cuter shaft is moving up and down how come this is remaining in position and nock moving up and down within that is it because the slain shaft can move through bodies without sharing its straight line motion.

But when the slain shaft is rotating it has to share it rotation or motion with another member which is connected to the slain shaft through teeth. So rmp is shared rotation is shared between this warm gear this one designated as z is $z2 = 50$ that means it has 500 teeth and the number of sorts from this warm is equal to one therefore the rotate together. Rather the warm gear makes the cutter shaft routine.

Now why does not the cutter shaft you know come out of a assembly here because it is still inside a rotational space okay. So it is giving a surface of you know revolution follow surface of revolution so it is no problem. It remains the position moves up and down and also rotates inside this embedded space. So now we have reciprocation of the cutter add it to this reciprocation. So as the previous we plan the cutter is now reciprocating as well as rotating.

This rotation is further down in this we have index gear box. So up till now we have come across the speedy box we connect across the speed gear box and we have index gear box here. The index gear box has its output giving to another yet or another warm here. Warm and warm a pair where the number could starts with good one and the number of teeth could 16 that could. So where we add we are add the work piece, if you remember the work piece has the rotation as well as a radial in speed in toward the cutter.

We have not you studied the radial in speed as an added line of you know mechanisms bringing the ultimate motion to the work piece towards the cutter but it definitely study this thing. At least while you know see and watching a video on the machine we definitely come across the radial in this. So this rotation ultimately rotates the work piece because if you remember in the gear shaping and the gear fobbing machines which work on generation we have to make the cutter and the work piece rotate individually okay.
By giving power to that, it is not that one of them drives the other. Because the simple reason that the work piece to start with does not have any teeth on it okay. So it has to made to rotate I mean the cutter in the work piece. What have to we made to rotate as if they are rolling against each other as pulley made gears. So that is what we have done, we have make the cutter rotate we have making the work piece rotates here and we will maintain the rpm ratio as if the work piece is already having the required number of these.

The cut has a fixed number of teeth this particular cutter not change it Okays. So now we are convince that the single motor source to be worked and some other mechanism we have discussed now. It is able to successfully reciprocate the cutter rotate the cutter as well as the rotate the work piece. And now it is good time to solve a problem and see what sort of no restrictions and other things defined arithmetically with the gear box ratios.

The question the questiu9on I I am cutting a gear of module to with 40 teethes okay. The module is to 40 teeth and I have not I have forgotten to mention is that the gear to be cut is a straights per gear okay. Not a helical here, so a straights per gear is being cut with module 2 and 40 teeth. So the cuter has 20 teeth that is good the, has 20 teeth the machine should be setup for 98 full strokes per minute.

What does it mean; it means that they will be 98 up and down movements of the cutter per minute fine. Now how we do this I have already providing you with the answer, so that you can tried up you selves before we discuss the solution and see that you have a correct answer. So the correct answer is Uv should be 14/15. Next question I I want a circumstantial speed of point 25 millimeters per full stroke of the cutter.

How do I achieve this? The answer is that you has the speed gear box should be such to a value of roughly 1/10. So it will set a value of 1/10 to the speed gear box you will be achieving in okay a circumstantial speed of point to 5 millimeters per full stroke of the cutter. So you might ask the question here justify as 0.25 millimeters of circumstance speed on the work piece will be the same thing the answer is yes.

Because when the cutter and the work piece they are rolling against to share without slain. They are supposed to have the same amount of circumferential moment. They share an equal circumferential movement therefore we can either say the circumferential speed on the cutter on 0.25 millimeter or circumferential speed on the work piece or circumferential speed on the work piece of 0.25 mm for full stroke.

Last of all how do I such the value of Ui ? The answer is Ui is defined by the number of teeth which is been cut okay number teeth which is been cut and the cutter number of teeth okay. So from that Ui the solution is Ui for the particular case will come out to the 3/5 okay. If you interested solve t he problem yourself and compare the answers when we come to the answers which have been provided.

And if you have any issues then when can share the solution and you can pick the look up. What might have gone wrong or may you are right and this discussion has some issues okay. So let us you should go through, and here we are having symbol which have discussed in case you have you know you have some doubts about some of the mechanisms this is warm and warm gear. There are other ways in which we are depicted it. This is a pair of bevel gear and this one is warm gear with slain in side which is fitting to this slain shaft okay so worm gear on a splinted shaft.

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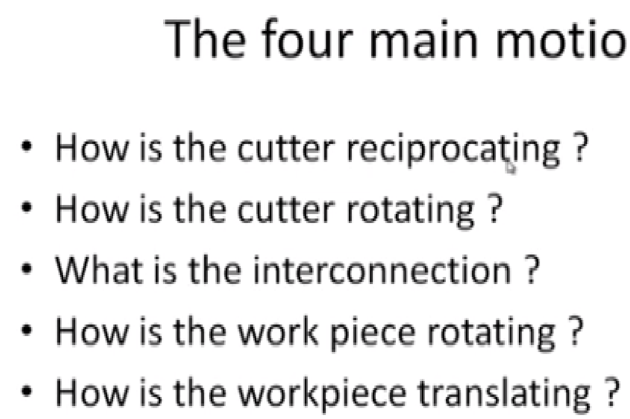

So the 4 min motions, how is the cutter reciprocating already discussed how is the cutter rotating already discussed what is the interconnection the splinted shaft part already discussed how is the work piece rotating we have already discussed this how is the work piece translating which means the radial in feed this we have discussed theoretically but with respect to a numerical problem we will definitely take this some.

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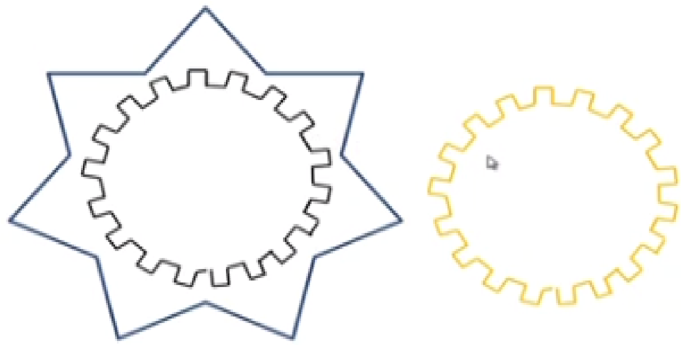

This is an example how the splinted shaft works suppose you have seen from the end once splinted shaft here splinted shaft is rotating and this is a member hypothetical virtual member which is you know a machine element with a hollow you know hollow interior with setting splint teeth so these teeth match exactly with these external teeth, so these are internally cut teeth in the hollow member these are external teeth so that if they are assembled.

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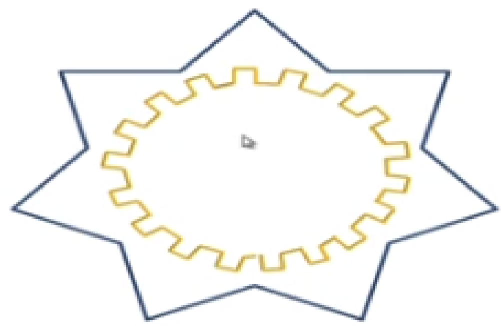

They will have the same rotations per minute this way okay inside the split shaft and outside there is this member and as we discussed they have you know they have translational independence while the this member might be translating the splint shaft might not.

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- If we start from the motor - we can write 1400 X Uv X (2/20) X (3/4)=98

- From which the value of Uv comes out to be Uv = 14/15

Now the solutions if we start from the I think we will try it out on pen and paper let us see.

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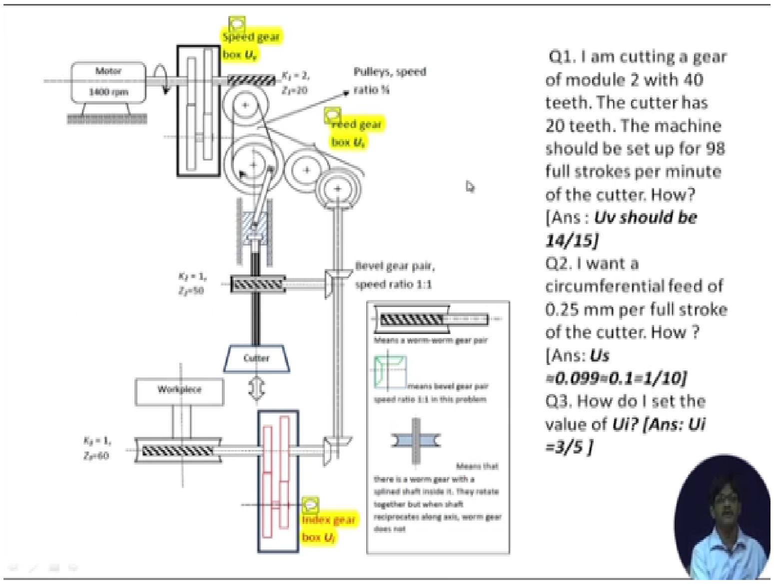

Yeah keeping this one let us try one pen and paper the solution for UV starting from the motor if you look at this paper okay.

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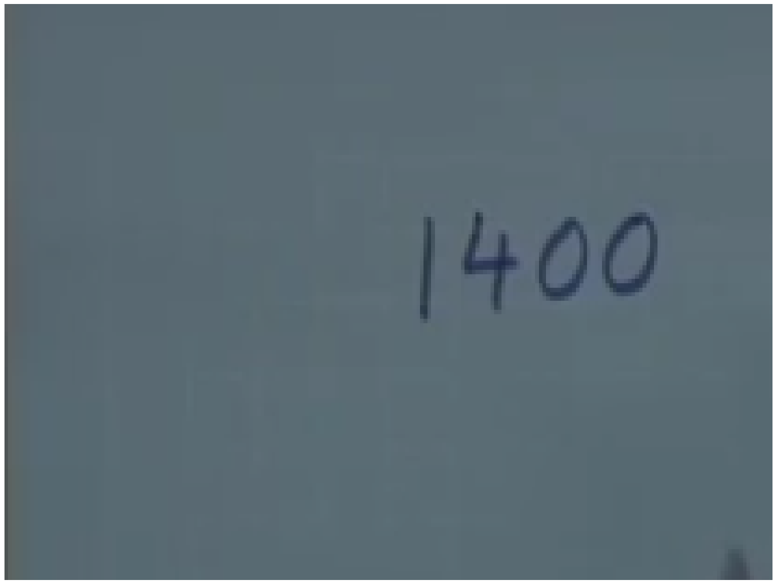

Starting from the motor we have 1400 RPM actually it should have been 1440 but nay way it does matter for the sack of calculations to understand the principle as good as 1440.

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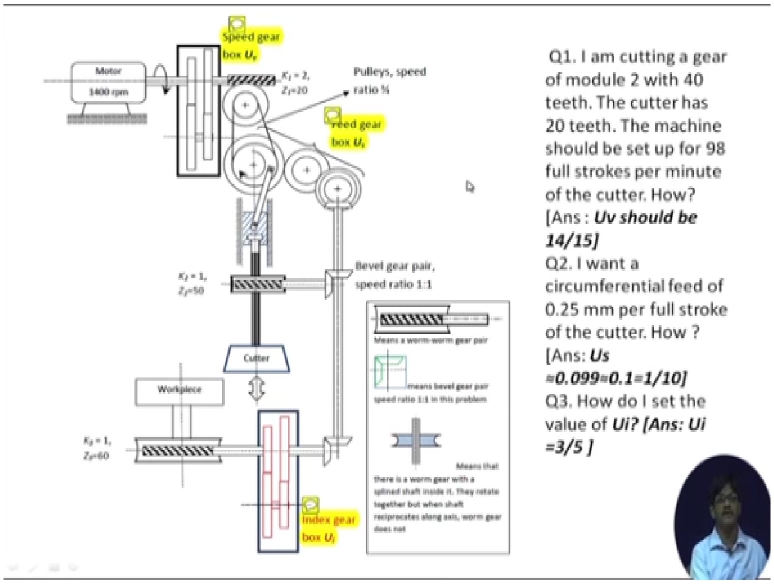

So we start with 1400 RPM.

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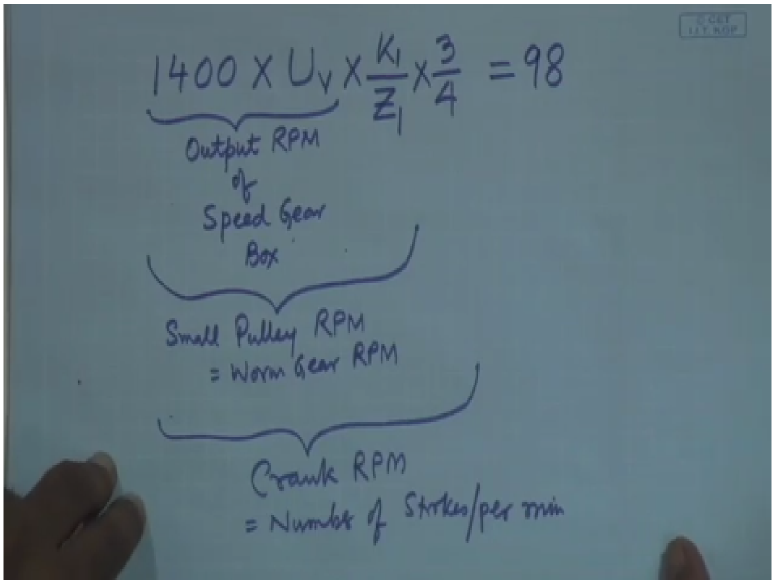

And then comes the speed gear box so we put U_V multiplied by, so once you multiple this since U_V = output RPM / input RPM this is the output RPM of the speed gear box alright, so if this is the output of gear must be shared with this particular.

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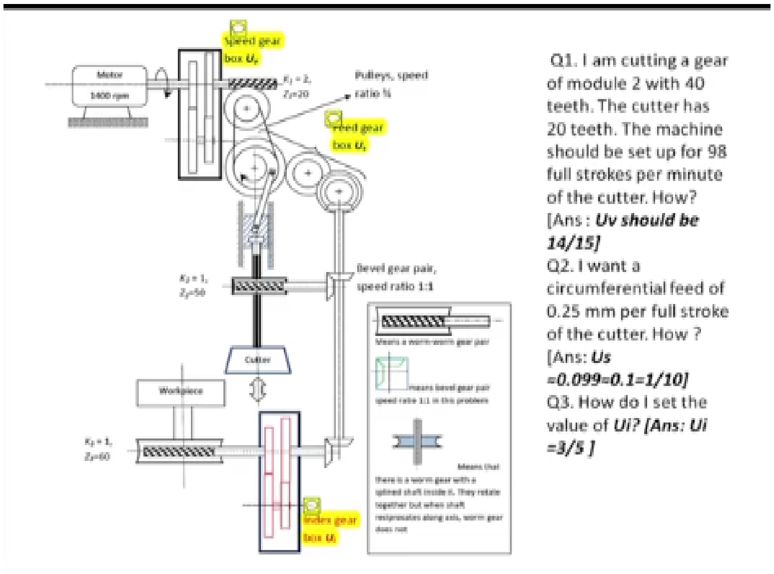

Box instead of box have this rpm and therefore just multiply this e ratio and the worm gear which is equal to K1 / Z1 so we come to the output, side of the worm and worm gear which ,means the worm gear rpm so worm gear rpm is shared with the fully, so if the pulley speed ratio is given this is the pulley rpm so we can write pulley small pulley rpm also the worm rpm = worm gear rpm, that would so once we you know past through the worm and worm sorry belt pulley if we notice in the figure it is written pulley speed ratio3 /4.

And everywhere we will assume that the speed ratio is given as output by input so that we can simply multiply this 3/ 4, okay so now we come to the correct, the crank rpm is this so we write crank rpm and this essentially is equal to number of strokes = number of strokes for that, so we have found out number of strokes per minute and we equate this to the number of stroke which is required and it is set 98 should be the number of stroke per minute that is it, now we can solve for Uv but even though it is 1 is in variable form so we have to replace this by this value so selecting a fresh sheet of paper we will write down 1400 x U_v x even by z1 is 2/ 20 x 3 /4 is equal to 98.

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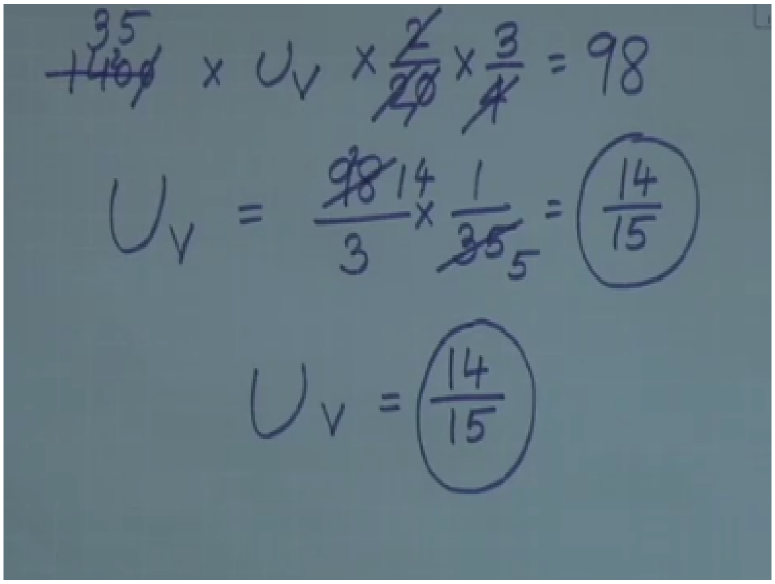

Once we have this let us solve for you, U_v comes out to be let us see lot of cancellation perhaps, yes 00,22 and 140, 4 will definitely cancel with it so we have 12, 3 and 2 so 5. So V ultimately comes out to be 98/3 and divided by 35 I think 7 will cancel so that we have a 5 here and what we have here, 1, 2,4, 14 so it comes out to be 14/15 sop answer is U_v = 15/15 that's it this is the answer alright.

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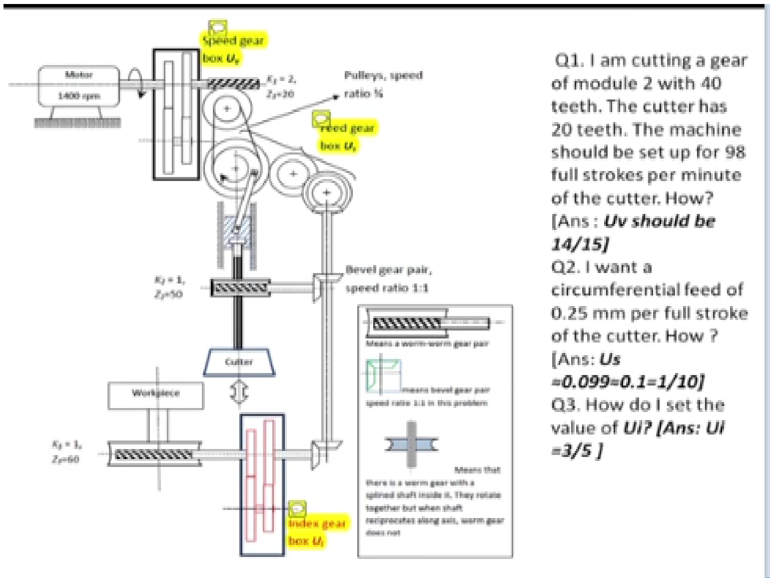

So let us take the next case. I think we are now on the second problem I want a circumferential fee of 0.25 mm per full stroke of the cutter, okay. Now in this case if you look at the figure okay we are starting from the cutter so for one stroke it will start moving from the cutter move backwards come to the mean line then move forwards and go to the rotation of the cutter and equate the circumferential movement to 0.25 mm okay.

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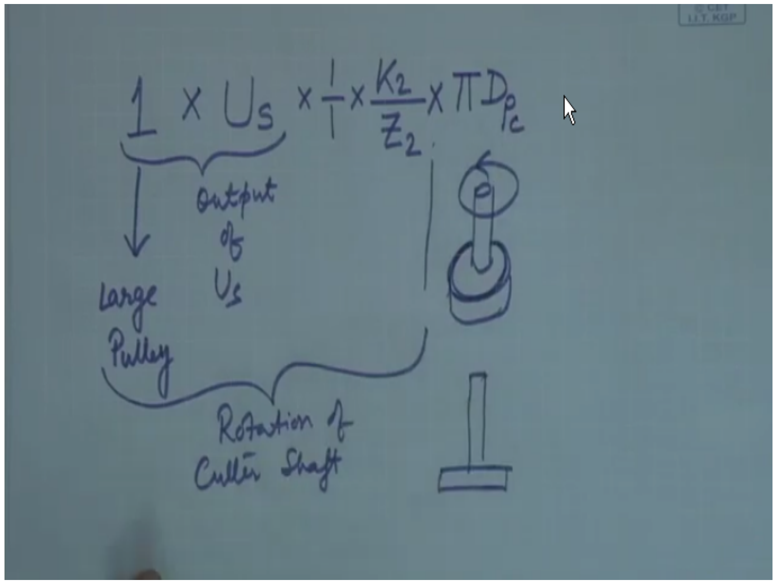

So let us do that so let us start from cutter reciprocation, cutter reciprocates once fully 1,2 up down therefore the large pulley okay, sorry yeah the large pulley, the large pulley rotates once fully during this time okay, so this one rotates once and therefore we can say the input to the feed gear box is only one rotation so once we give one rotation to the feed gear box it outputs Us number of rotations and this passes through this one, passes through this worm and worm gear and ultimately rotates this particular gear, let us find it out.

First of all one rotation, sorry one reciprocation of the cutter equal to rotation of the large pulley so we write large pulley we are talking about rotations that is good, this one will when multiplied so this is input to the gear box Us feed gear box so the output of the feed gear box must be equal to 1xUs this is always expressed as output by input, so multiplied by input only output remains, output to the so we will write output of U_s that is it so after that after us we pass through the feed gear pair so we multiply 1/1 actually there is no need of doing that anyway to keep track of the mechanism which we go through and other 1/ 1 will be there and after that we pass through the worm and worm here, in what way k2 = 1 k2 /z2 and therefore we are now on the cutter shaft ion the form of rotations.

So we can write rotation of cutter shaft however cutter shaft rotation is not specified in any manner but cutters circumferential movement is specified, so let us find out for these many rotations how much is the cutter circumferential movement what is the circumferential movement for one rotation of the cutter definitely πd that mean one full circumferential that is if the cutter is here or rather let us try isometric form yeah, if the cutter is here if this rotates once completely how much is the circumferential movement of the cutter definitely equal to one circumference therefore if you have x number of rotations of the cutter this we know rotation of cutter shaft.

So amount of circumferential movement on the pitch circle must be simply equal to πd this thing to the πd one rotation πd amount of circumferential movement x rotation x*πd so this multiply by πd were D_p is the cutter pitch diameter now this can be simplify so we write the this finally equal to cutter circumferential oh my god align is here cutter is here circumferential above making cutter circumferential movement for one stroke okay.

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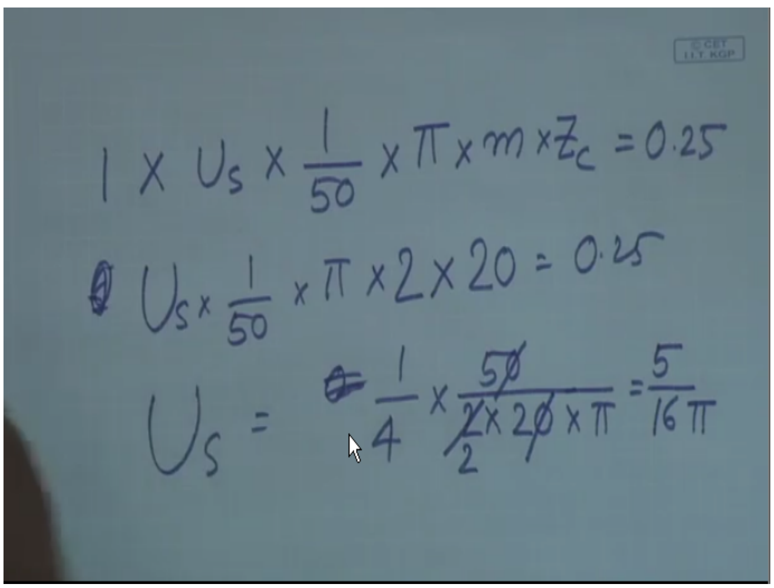

So let’s now just find out how much is this 1* U_S*1/50 multiply by π*D_{pc} what is D_{pc} the cutter pitch diameter that must be equal to m*z so m has given to be m *z z means cutter number of p equal to this must be equal to .25 this circumferential movement must be equal to .25 mm and for that we will sort U_s so once again all this things, this thing is the rotation of the cutter for one stroke and I multiply the circumference I gave the circumferential movement and I equated to .25 mm which is the circumferential movement off cutter, having understood this.

I have quickly find out what is Us by the way let me just put in this value, final worm Us x 1/50 x π X m what is m 2 given, number of teeth on cutter 20 = 0.25mm which is given, so Ys is solved as 0.25 let us put in $1/4^{th}$ x 2 x20 and down goes π up goes 50 and this one as the solution, let see how much it is 0 and 0 will cancel 2 no 2 will not cancel sorry.

This will be 5/ how much is this 8, 2x2 4, 16 5/16 π I have made a mistake let me check, hopefully this is correct, I will just compare this with the calculation which we have already done. I will see whether we have got something, so yeah Us x 1/50 x π 2 x 20 = 0.25 and hence we have solved it and got a particular value. So I don to have the calculator as you can quickly calculate it whether it comes out to be 1/10 roughly, that is 0.099 so it is been made to be 0.1 that is 1/10.

So if you put in this particular field in the gear box value you will get a circumferential feed of 0.25 mm so with this we come to an end of this lecture we will take up the rest part of the problem in the subsequent lecture thank you very much.