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NPTEL ONLINE CERTIFICATION COURSE

Course
On
Spur and Helical Gear Cutting

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Lecture 10: Numerical Problems on Gear Milling

Welcome viewers to the 10th lecture of the.

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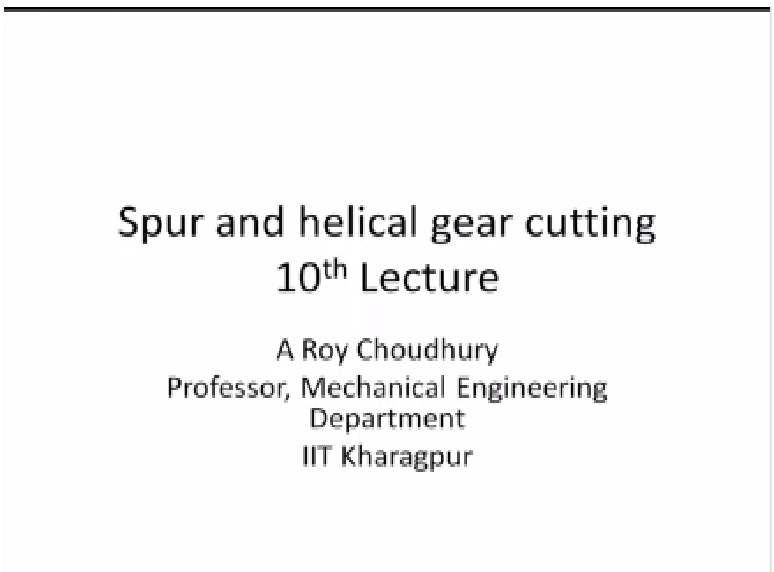

Of the course spar and helical gear cutting and in this tenth lecture we will be solving some numerical problems on the subjects that we have covered up till now.

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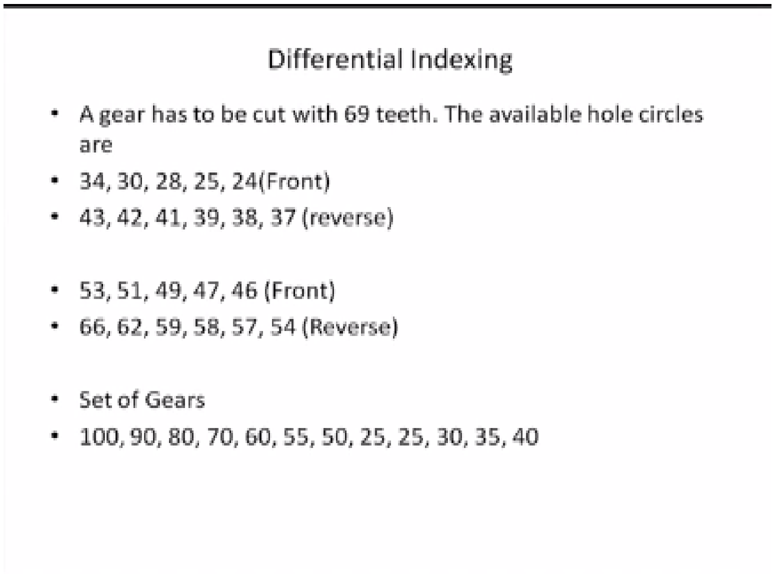

So let us move on directly to those subjects first comes the question of differential indexing, gear has to be cut 69 teeth the available hole circles are okay, some hole circles that means on the index plate, we are having some holes present and the old circles which are available they are put here, that is fine so the thing to be noticed is that the highest value is 66 okay and the set of gears which are available they are 100, 90, 80 etc. Now what are we supposed to do with these gears? If a change gear ratio is to be developed by setting up a gearbox between, you know the worm gear and the index plate as is generally the case in differential indexing.

Then we can make use of these gears okay, so this is the statement of the problem I have to cut a give it 69 teeth available hole circles are provided and the set of gears change gears they are also provided, now let us see how we can solve this problem.

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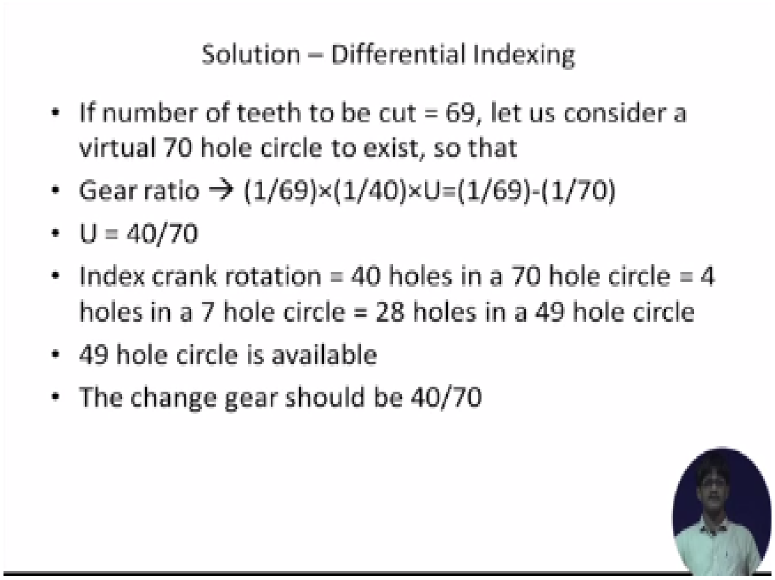

First of all if 69 teeth are to be cut, we can first of all move / the method of virtual whole circle. Now what is that? We say that 69 teeth had to be cut and we do not have some whole circle which is very close to it, say 70 whole circles, so we assume that 70 whole circles is present, now why are we doing that? because in that case the gear issue becomes very simple but if you do not have something how can you proceed with the calculations because many times it is seen that the fractions which will be and you know appearing in the calculations, they can be realized / other gear boxes or other whole circles as well.

So let us precede frame the method and see whether it is and giving acceptable answers, so the gear ratio how do we calculate the gear ratio? For that please have a look at a paper.

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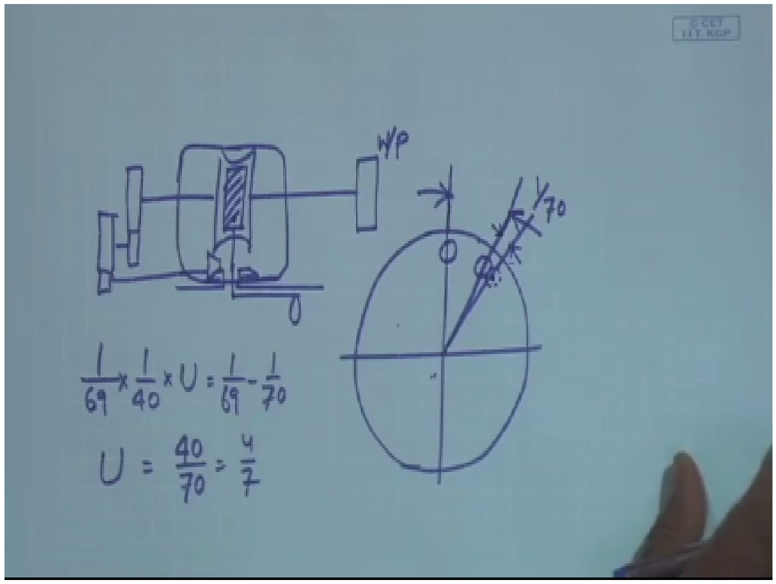

What we generally do just to remind you is this that we have this dividing head on the dividing head we have this particular you know index crank sticking out this is the index plate and this gets connected to the worm, this one to the worm gear bomb gear feeds the work piece that is your blank on this side, on this side we have those gears etc. This one connects up through a bevel gear to the index plate, the drawing hopefully is clear I can I can show you another drawing but you will find in the previous lectures we have already discussed it so index crank rotating moves right through rotates, the worm rotates the worm gear and that rotates the job and the worm gear feeds back this particular data, I mean its rotation to this change gears and they connect up this part is not very clear but they connect up to the index plate index plate rotates.

Now this index plate when it is rotating it creates a differential motion between the rotating crank and the rotating index plate, this is what we are interested and how does it occur here this is the figure, in the figure this is the existing 1st hole existing 2nd hole and therefore we can say that this distance must be, this distance must be 1 /70 this is what is physically provided to you. 1 hole 2nd or 3rd hole photo like that now if 1/ 69 sorry, if 69 whole circle is not there had it been there from the 1st hole 2nd hole would have been slightly away here and therefore as per method of differential indexing /line moving the crank from here towards this side okay.

This hole that means this hole which is on the plate the plate should travel so that this hole comes here and therefore the movement on the plate required is this one. How much is this? must be 1/ 69- 1 /70, so now we move from the worm I move from the index crank this way that the movement that I am ultimately providing therefore / index crank must be 1/ 69 I am travelling right up at this point plate is traveling from here to here, so1/ 69 x so 1 / 60 and rotation has been given it goes here and suffers a reduction of 1/ 40 gets x / u, rotates the index plate index plate is rotating / this much amount 1/ 69- 1 / 70.

So that basically we have derived the equation once again, 69 will cancel out and we will have 40 /70, this will yield a numerator of 1, denominator 69 will cancel out and 70 will remain, so the change gear has to be 40 / 70 having a virtual whole circle of 70 holes, it is not there this is the gear ratio connected up with this particular whole circuit. Now this means that the gear ratio is basically 4/7, so if you can provide a gear ratio of 4/7 at this point the index plate will have the required motion for indexing for a 70 whole circle.

This is understood for 70 whole circles if we have exactly the motion required if you put here 4/7, so how much is the movement of the crank which is required? As we know the magic number is 40 let me choose a different piece of paper.

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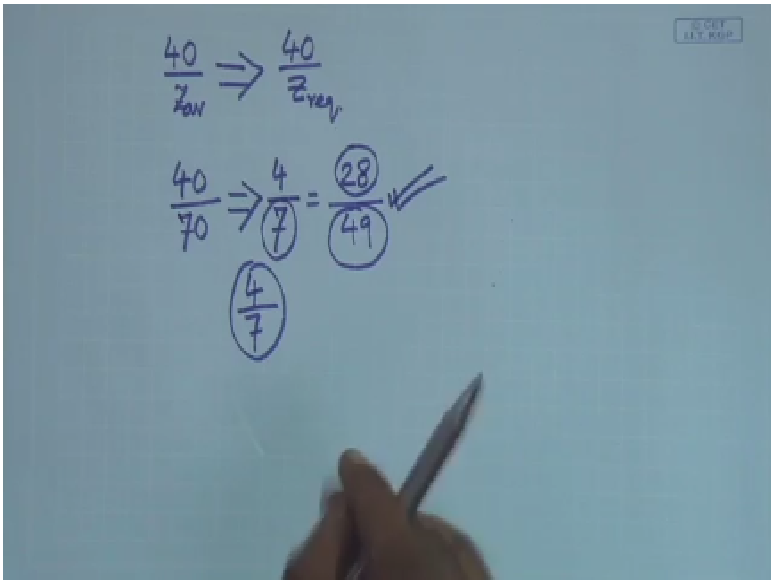

As we know the magic number is 40 / Z okay and in differential indexing what happens the Z required is not there, so move / 40 / Z available and the Machine will add adjust through the mechanisms that change here and all those things this will be converted to 40 / Z gets converted to 40 /Z the required that is a function of that gearbox and all those things okay, so in this case how much do we have to rotate the crank we have to rotate the crank / 40/ 70. That means had you not had a 70 whole circle but a 7 whole circle you would have to would have had to rotate the crank / 4 parts out of 7 parts.

Out of one rotation 7th of rotation would have had to be done, so in that case we understand that all that virtual for 70 whole circle etc that is not important but what is important is this ratio, this rotational amount has to be provided that is all, you might not have a 70 whole circle it does not really matter is a rotational amount is this 4/7 of a rotation as we provided / whatever means, so that means that if I have a seven whole circle or any multiple of it then that will do and we look up that particular table let us have a quick look at this table yeah we have multiples of 7 14 49 is there 42 is there okay all sorts of multiples of 7 they are present.

So coming back what we do is sorry coming back what we do is, we multiply / 7 the numerator and denominator we come up with7 X4 28 7 x 7 the 49 on the 49 whole circle if you move / 28 holes that will suffice, you need not have 70 whole circle but mathematically we see the only restriction is 4/7 of a rotation as we provided in and to make a differential mechanism they will take care of everything else okay. So this is the answer 28 holes on the 49 whole circle have to be moved through and you will be cutting 60 90, the change gear ratio has to be 4/7 that is it if you do these two things your problem is solved.

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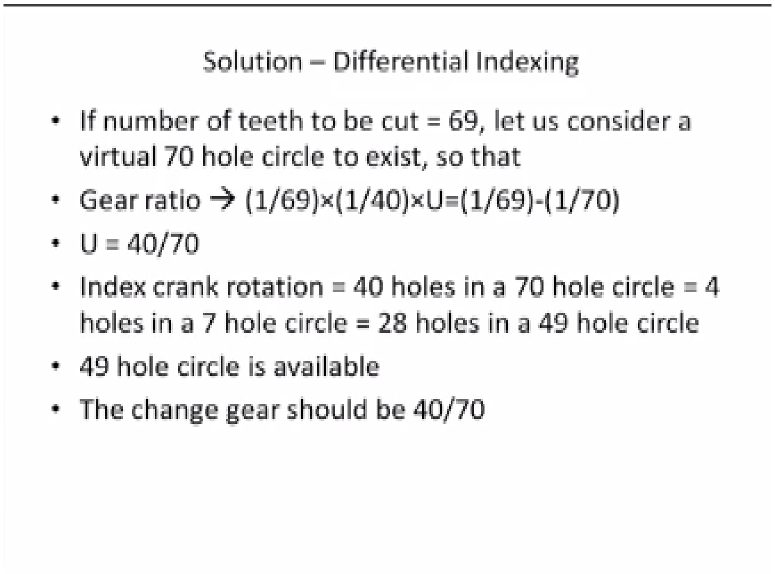

Next let us take a corollary okay if you if you if you have this problem on the same machine how would you be cutting 71 whole circles? the 71 whole circle can be cut with this same setup only an extra pinion would be required to change the direction of rotation instead of, you know the rotations taking place in the same direction crank rotation and plate rotation taking place in the same direction crank rotation and plate rotation will be opposing each other if you cut 71 holes up other things will be remaining the same okay. So this is one problem in differential indexing let us move to yet another problem.

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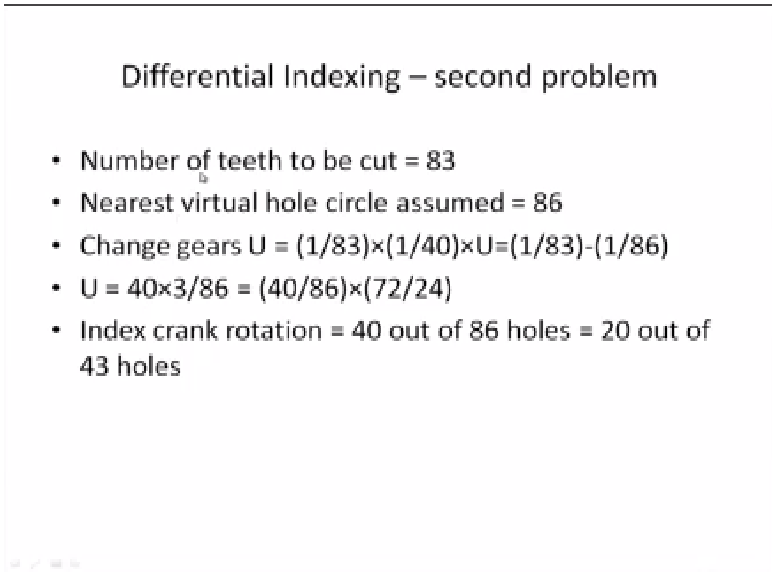

Say number of teeth to be cut is 83 and nearest virtual old circle which is provided okay I am saying please use 86 whole circle, so this time I am not leaving it to you where you assume 70whole circle but this time we are providing we resume a virtual whole circle of 86 and solve the problem okay so the change gears so this time the change gears we can directly apply the formula instead of deriving it.

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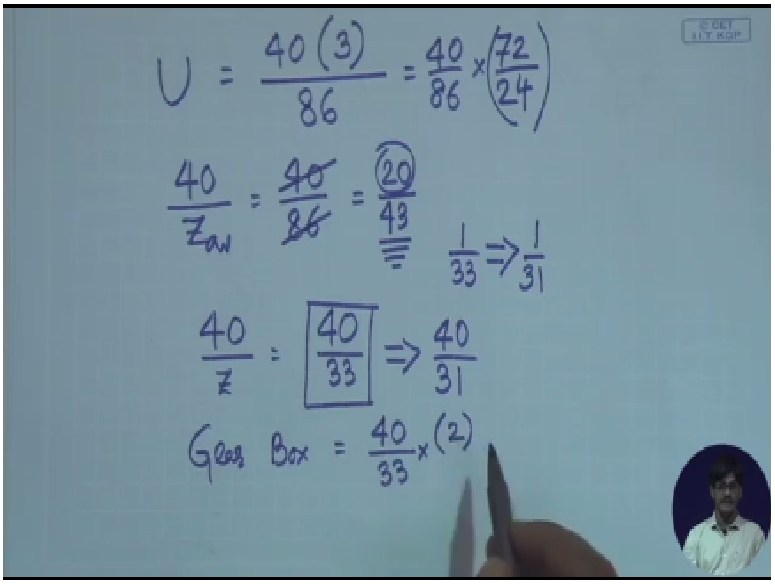

U is = 40 x n required - n available which is 83 - sorry 86 - 83 is 3 / available whole circle 86 okay, so this is 40 / 86 x 3 from the change gear is available you will find that you can use 72/ 24 yeah are right for 3 for 12 and 3 to the 6, 7 ok this will give you 3, so these change gears in the in the gear box they will provide you with the required particular gear ratio and what about the actual rotation of the crank ? once again40 / Z is the magic number 40 / Z available must be = 40 /86, that means we can cut it at least once and we can get 20 / 43, that means if you have a 43 whole circle in that case if you move by 20 holes that will also suffice ok that will also suffice.

So if you use so coming back to here if you use a 43 whole circle / twenty holes on that that will suffice but why not use 86 because it is mentioned already agencies does not exist, so how do I know 43 exists, 43 has to exist otherwise this problem can only be solved okay, so I am sorry in the statement of the problem we should have said that 43 whole circle is existing and solve the problem by assuming 86 is the nearest virtual hole available okay, sorry but that would have made it a fully you know full proof problem okay.

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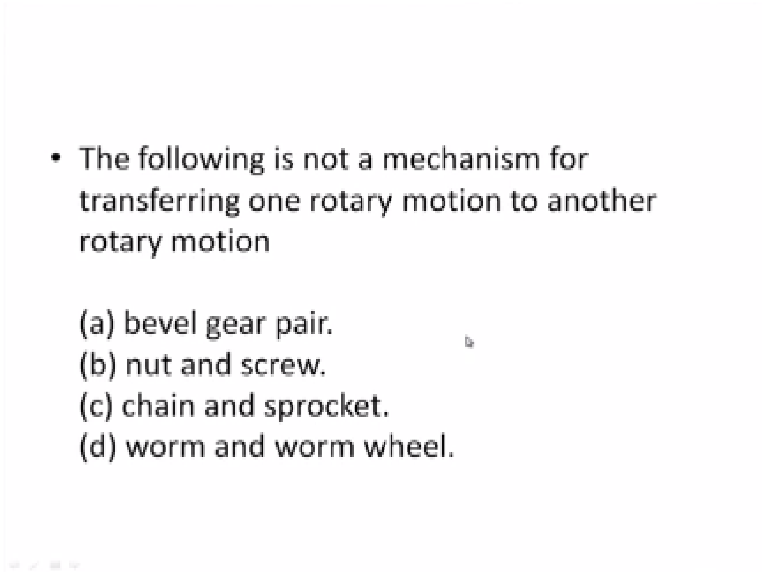

So let us tryout some problems of you know this type which will which will be helping you to apply logic to find out the answers to several multiple-choice questions, the following is not a mechanism for transferring one rotary motion to another rotary motion bevel gears pair nut and screw, chain and sprocket, worm and warm wheel, so does the bevel gear pair transfer one rotary motion to another? Yes it does so this is not the answer, nothing screw nothing screw yes provided the screw is you know restricted from translation and that is restricted from location transfer from rotary motion to linear motion takes place.

So this mechanism is not for transferring rotary motion to rotary motion, you might say that if I love the nut with this screw that means, then screw is rotating on top of that the nut is mounted therefore nut is also rotating, so we have to add another statement to the question that nut is restricted from rotation with the screw but that will be a giveaway you are already telling answer anyway let us go through the other options. Chain and sprocket chain and sprocket is basically used for rotary motion two rotary motion because the power ultimately transfer gets transferred from sprocket to sprocket.

But suppose I argue this way that at least from the chain to the sprocket since it is mentioned as the as the pair change to the sprocket translation to a rotation to translation is taking place sorry sprocket to chain rotation translation is taking place, so that way this will also qualify strictly speaking in a chain sprocket mechanism, then the sprocket is rotating the chain is undergoing linear motion okay, so see also qualifies worm and worm wheel, if the worm rotates the warm wheel rotates, so this is for rotary to rotate it so here if we look at the answers strictly from a logical point of view nothing screw qualifies chain and sprocket qualified.

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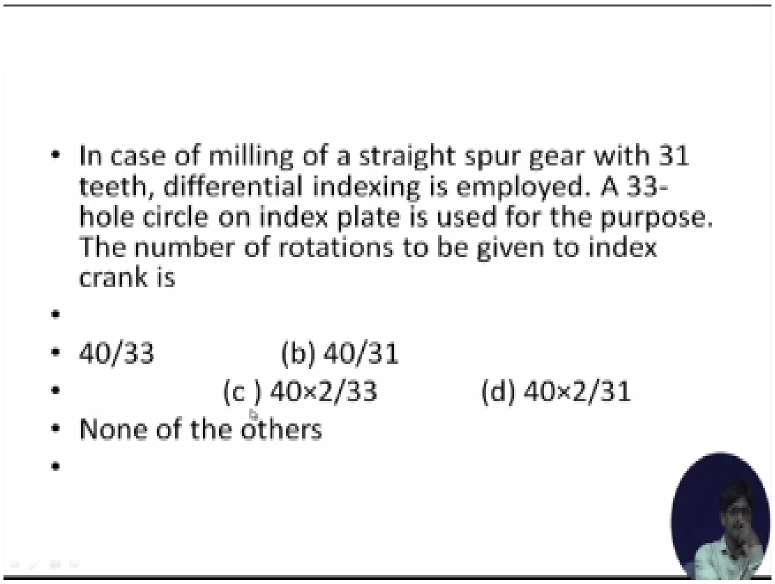

In case of milling of a straight spur gear with 31teeth differential mixing is employed a 33 whole circle on index plate is used for the purpose the number of rotations to be given to index crank is, so this is now very simple for you people because you have already done two problems, so here we will simply apply for 40 / Z x that means 40 / Z available x and the solvent what is asked for the number of rotations to be given to index crank. What is the number of rotations? mind you there will be one question in which you will be asking for the gear ratio and another question where you will be asked for the number of rotations of the crank. So in this case let us find out what is the number of rotations of the index crack if then if the rotations of the index crank they are taking place as let us write it down.

40 / Z okay what is the Z available? The Z available is 40 / 33, 40/ 33 and we are cutting 31 teeth, so if we give if we provide 40 / 33amount of motion ultimately it will be converted to 40 / 31 okay, how is this need possible? because ultimately if we are providing 1 / 33 of a rotation it is getting converted to 1 / 31^{st} of a rotation, so 40 / 33 will be getting converted to 40 / 31, so the answer should b 40 / 31 be, here I should mention that if gearbox had been asked for gearbox, it would have had this particular answer 40 / n available x n n1 - n2 n, that would give us 2 in that case we would have been correct but gearbox has not been asked for and mind you there is a sign which is appearing here which can change indicating direction of rotation.

We will come to that in some problem which is given later on okay so the answer to this is simply 40 / 33, 40 / 33 sorry b is not the answer I made a mistake 40 / 33 is e 40 / 33.

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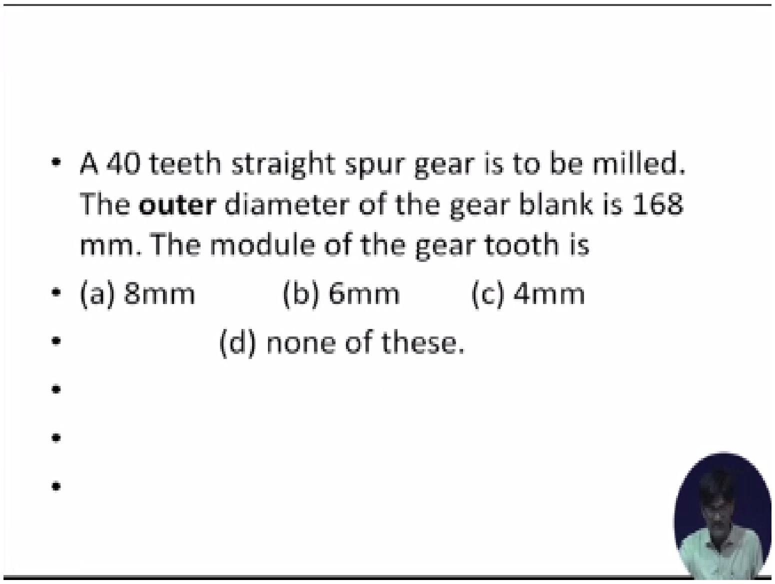

40 teeth straight spur gear is to be milled the outer diameter is 160 millimeters the module of the gear too this, so how do we solve this question we say that the outer diameter of the gear blank in case of straight spur gear is.

We will write it down here diameter out = D_P + 2 module = m xZ + 2 m = we have 40 teeth so let the module be m x 40 + twice m and this is given to be 168 okay, so 42 m is = 168 which means m is = 4 okay so m is = 4.

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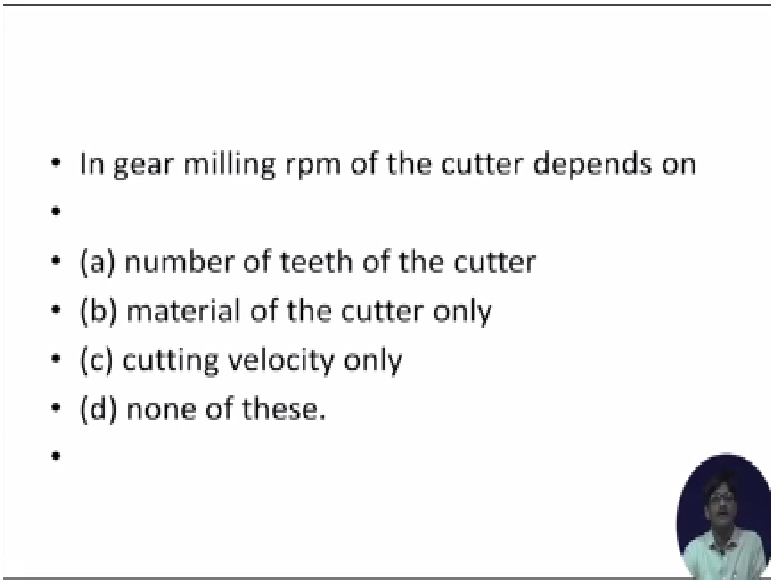

In gear milling rpm of the cutter depends on number of teeth of the cutter material of the cutter only cutting velocity only, and none of these, so let us look at them one by one in gear milling rpm of the cutter depends on the number of teeth of the cutter why should it there is no reason because of which it should depend cutting speed which is sorry rpm. Which it is developing it should be related to the cutting speed not the number of teeth so it depends upon the material of the cutter only it depends on the material of the cutter but it does not depend upon it only there are other factors also on which it will depend.

Cutting velocity only now if the cutting velocity is mentioned for the cutter okay does that define the rpm no cutting speed is defined by you know defined as π DN / π DN / 60, where D is the diameter of the cutter and n is the rpm, so if velocity is = diameter x rpm so velocity depends sorry rpm depends both upon the cutting velocity as well as upon the diameter, so rpm depends both on cutting velocity as well as on it is diameter, so not it does not depend upon cutting velocity only so here we have the answer to be none of these it does not depend it does not depend upon number of teeth it does not depend upon material of the cutter only, it does not depend upon the contain cutting velocity only, therefore the answer is none of these.

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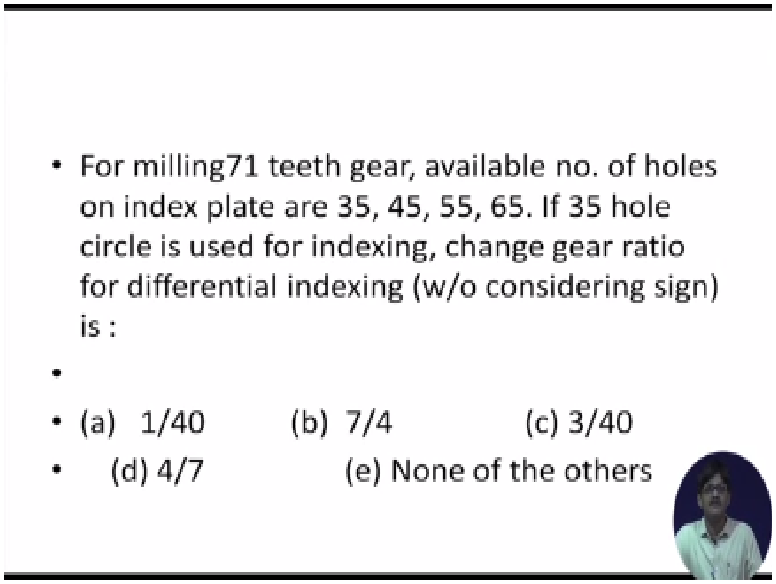

For milling 71 teeth here available number of holes on the index plate are 35, 45, 55, 65, a 35 volt circle is used for indexing change gear ratio now we are asking for change gear ratio, so we have to be very alert change gear ratio for differential next thing without considering sign for the time being we are not bothered about the sign is, so some options are given so let us quickly apply the equation for gearbox.

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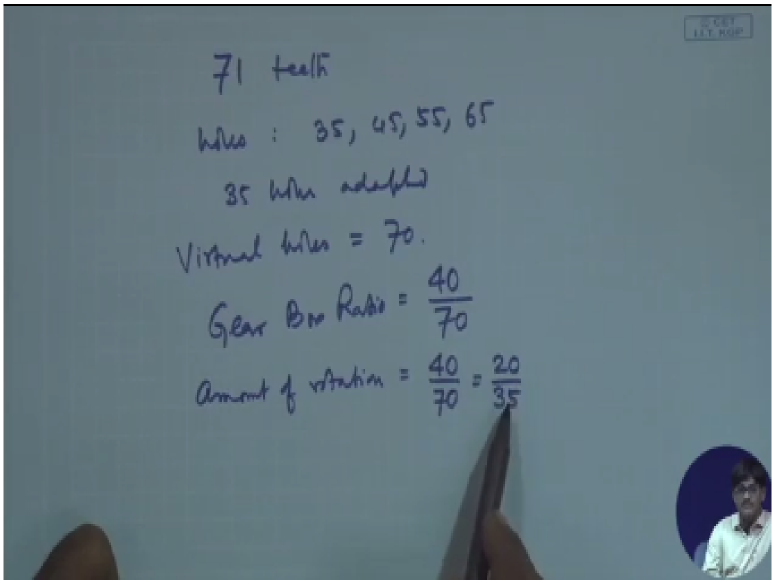

So gearbox = ratio 40 / available number of holes 40 / available number of holes is just a moment we will let me let me write down the problem on a fresh piece of paper 71 teeth okay holes available 35, 45, 55, 65, 35 holes adapted and with this, how much should be the change gear ratio, so let us take a virtual number of holes 70 immediately we can understand that if 70 holes are present the gearbox ratio becomes 40 / 70 that is it40 / 17 4 / 7.

So let us see whether that answer is there 4 / 7, you might say that what about the virtual thing that has been mentioned here it means that, if I can apply this particular gear ratio and work with the 70 whole circle we have nothing to worry about but then you will be saying that 70 Oh circle is not this but if the with the whole circle our main headache is that, whether I can execute the required amount of rotation on that whole circle so how much is the amount of rotation.

The amount of rotation is if we look at the piece of paper amount of rotation must be = 40 / 70 40 / magic number that is converted to 40 / 71 so if it is 40 / 70 it is as good as 20 holes on the 35 whole circle, so we have nothing to worry about we will be having this gear ratio it will be taking care of the conversion and the amount of rotation which is 40 / 70 it can as well we of be obtained /20 / 35 it is giving going to give rise to the same fractional movement okay, so both these things are satisfied and therefore answer should be 4 / 7, so let us go back to the problem and have a look at the options.

The change gear ratio for differential indexing is 1 /40 3 / 40 4 / 7, 7/4 so D is the correct answer the gear ratio 4 / 7 going back.

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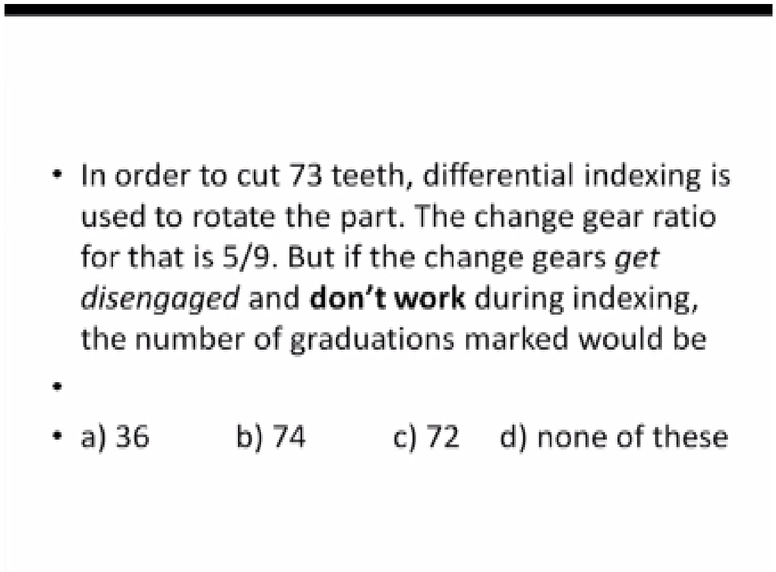

And taking the next problem let us see what it says in order to cut 7 to 3tdifferential indexing is used to rotate the part the change gear ratio for this is 5/9 but if the change gear get disengaged and do not both dealing indexing the number of graduations marked would be just a word I am sorry the last line should be the number of teeth cut would be, so let me read out the problem once again in order to cut 73 teeth differential indexing is used the change gear ratio is 5/9, so you have put a particular gear ratio from this we can back calculate what is the number of holes that you are employing, but if the change gives get disengaged the number of teeth that would be cut is, so let us solve this problem.

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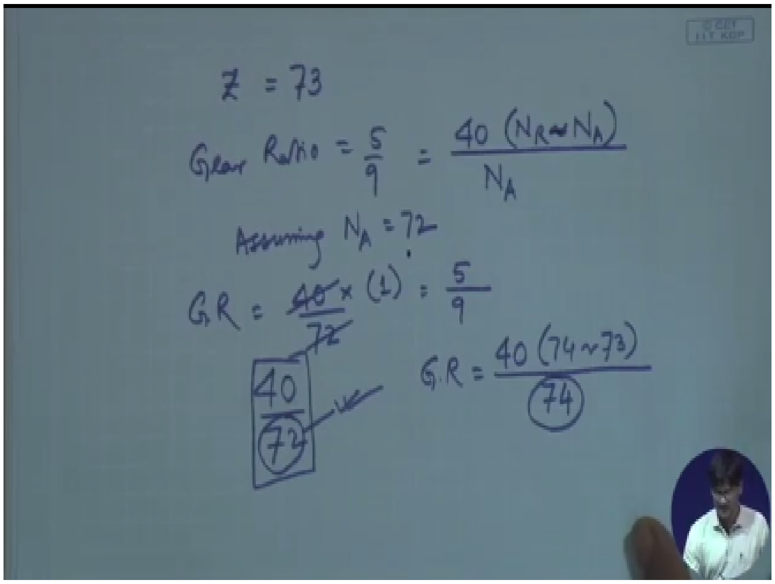

If you look at this piece of paper so we write here read is = 73 teeth okay gear ratio = 5 / 9 that must be = 40 / N available x n required - N available let it has a difference because we are not considering the sign of this moment, so if this is 5 / 9 we can we can have right if we take assuming let us try the solution assuming N a to be 72 okay then gear ratio comes out to be 40 / 72 x1 = this cancels out how many times can cancel / 8 5 are 40 + 9 x 8 72 that is it.

So if must be working width of a whole circle or a virtual whole circle of 72 but what is the problem is the gears suddenly get disengaged and when the operator goes on using the setup he is basically not doing differential indexing but he is doing simple indexing with 72 all circle and therefore the number of teeth which are being cut they are defined /40 / 72 this is the number of teeth which are being cut if it gets disengaged from differential mixing.

So 72 teeth will be cut in that case okay a one question one question what about 74 can 74 be an answer let us see in that case the gear ratio if you come to the piece of paper once again gear ratio with 74 how much is it 40 x 74 difference 73 and 74 Oh 74 is going to you know drive the solution somewhere else 40 / 74 is not = 5 / 9, so we have this to be the answer is 72 is the correct answer coming to the next problem.

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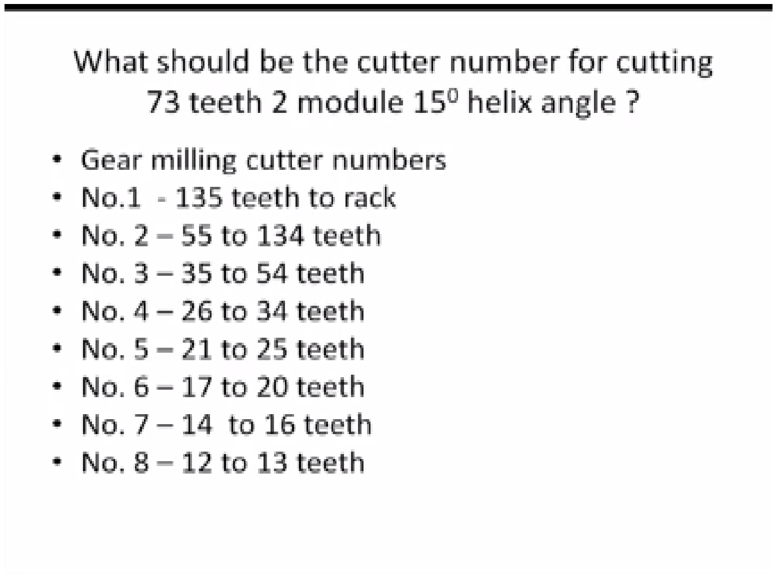

What should be the cutter number for cutting 73 to module 15^0 Alex angle gear, so what is the information that is provided first of all once again the statement of the problem is what should be the cutter number for cutting 73 t2 module 15^0 helix angles gear teeth / milling obviously because some milling cutter numbers are given what is that information cutter number one cuts from 135 feet to the rack cutter number 2 from 55 to 130 40 cutter number 3 35to 54 teeth number 4 26 to 34 teeth number 5 21to 25 feet number 6 etc.

Now what is basically the thing that we notice we find that for small number of teeth the knob cutter numbers are rapidly changing as the numbers of teeth becomes become you know larger and larger the tooth profile becomes more and more flat and ultimately we find that you know the cutter numbers can handle huge numbers of teeth single-handedly. Cutter number 2 for example can handle 55 to 130 40 so with this idea in mind let us proceed first of all our first thing that we notice in the calculations is that.

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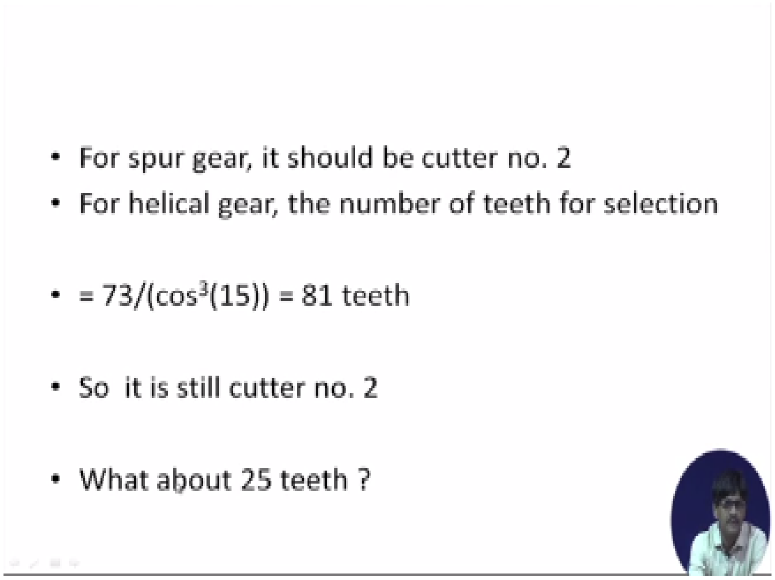

For spur gears what should be a cutter number the cutter number should be 2 why because if we go back if we are cutting 73 teeth it falls in this particular category 55 to 130 40 and cutter number 2 should be used that is good so for helical gear the number for selection of teeth the number of teeth for selection should be given / n / cos Q α or Z / $\cos^3$ α, so α is given to be $15^0$and we do this calculation that number of T divided / $\cos^3$ α is = 81.

So 81 means that it is still cutter number T it is still cutting number two why because the certain number 2 can handle from 55 to 130 14, so if you go for looking for any you know change in cutter number most of the cases where you have a small cutter number you will notice that in that case the there is there is frequent chance of the cutter number getting changed cut a number getting changed okay.

So 25 teeth if you have 25 teeth with helicangel l 15^0 you are surely going to have a change I have not included this calculation but you can do it very simply that is the effective number of teeth for selection of the cutter will be 25 divided / cos cube 15 okay cos cube 15^0 that will give you the number of teeth which will be used for selection of the cutter okay thank you.