Spur and Helical Gear Cutting
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Lecture – 34
Gear Shaping - IV

Welcome to the 14th lecture on Spur and Helical Gear Cutting and we were discussing one numerical problem on gear shaping, spur gear shaping on the fellow’s gear shaper and let us continue with the last part of the problem. So, let us quickly go to the problem statement.

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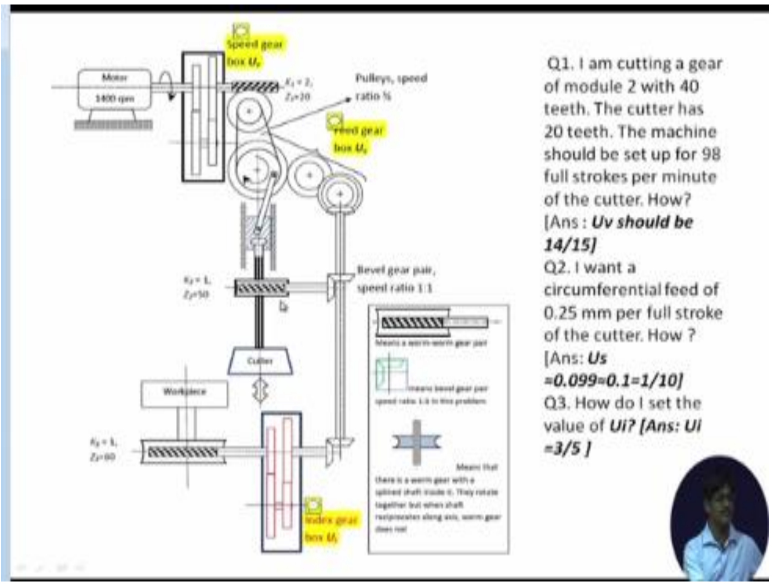

This is it. We have up till now finished up to this point that is the second question and we were discussing this cutting of a spur gear on the fellow’s gear shaper. The Fellow’s Gear Shaper works on the principle of generation. So, last question that we have left is how do I set the value of U_i. Now, if you recall the discussion in the last lecture, U_i is situated here and U_i is decided by the number of teeth that we are going to cut.

What is the number of teeth that we are going to cut? We are cutting a gear of 40 teeth. And what is the basic idea? The idea is that U_i should be set to such a value that the rotations that I am providing to the cutter and the work piece should be exactly equal to the inverse ratio of the numbers of teeth on the cutter and the work piece. So, that they will be rotating as if they are rolling with 20 and 40 teeth respectively.

So, the cutter is having 20 teeth and the cutter should be having rotational speed exactly twice of that of the work piece because 20 teeth and 40 the inverse ratio is defining a speed ratio that way of that much. So, how do we solve it? What we do here is that we can start moving from the cutter, move backwards, right tthrough these machine elements, come to the main line and then you simply go forward and come to the work piece.

And whatever rotations per minute, you come up with equate it to the value of the rotations that is required. So, let us start it right away. Suppose, the cutter is rotating once. If the cutter rotates once, how many times do you think the worm gear is rotating here? This one, the worm gear must be rotating once also because they are sharing RPM. If the worm gear is rotating once, how many times do you think the worm will rotate?

Surely, the worm is going to rotate at a much higher rate given by this ratio $\frac{1}{50}$. So, if a worm rotates 50 times, it makes the worm gear rotate once. So, here, if the worm gear is rotating once, we come up with the idea that the worm is rotating 50 times. So, when we move backwards through machine elements, then we take their reverse speed ratios. Generally, when we are moving forward from worm to worm gear, we get $\frac{1}{50}$ here.

And here, we will get $\frac{50}{1}$ when we are moving backwards. So, let us start writing down the values.

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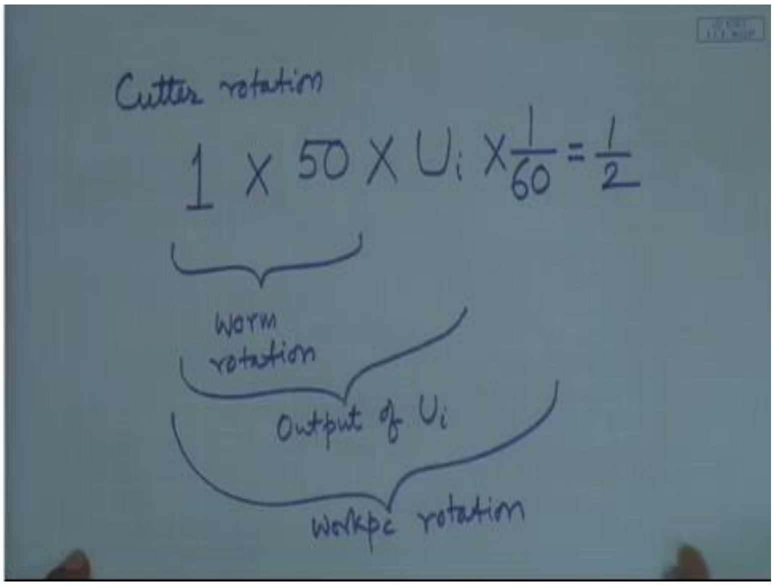

First of all, we put the cutter rotation to be 1. Since it is the same as the worm rotation, then we multiplied by $\frac{50}{1}$, the reverse ratio to get the worm rotation. After that through the bevel gear pair, we come to the main line. It is just like a car backing off from a by-lane on to the main road.

$$1 \times \frac{50}{1} = \text{worm rotation}$$

So, you are going reverse and after reversing, you come to the main road that means the National Highway and then you are moving forwards and when we are moving forwards, all the ratios will again be taken as the straight ratios, not reverse. So, now, we move through to 2 bevel gear pairs come down and enter U_i so that at the output of U_i, this will be the rotation. So, we write output of U_i, output of the index gearbox.

$$1 \times 50 \times U_i = \text{Output of } U_i$$

After this, we have a worm and worm gear pair and it is given $K_3 = 1$ and $Z_3 = 60$. So, we have $\frac{1}{60}$. Now, the ratios are not in reverse anymore because we are moving forward through the machine elements. Worm to worm gear we are moving. So, this must be equal to the work piece rotation and let us equate it to the work piece rotations that we would have for 1 rotation of the cutter.

For 1 rotation of the cutter, the work piece rotates only half the times and we put it to be half here. So, that is it. We get the work piece rotation here. Now, let us solve for U_i.

$$1 \times 50 \times U_i \times \frac{1}{60} = \frac{1}{2}$$

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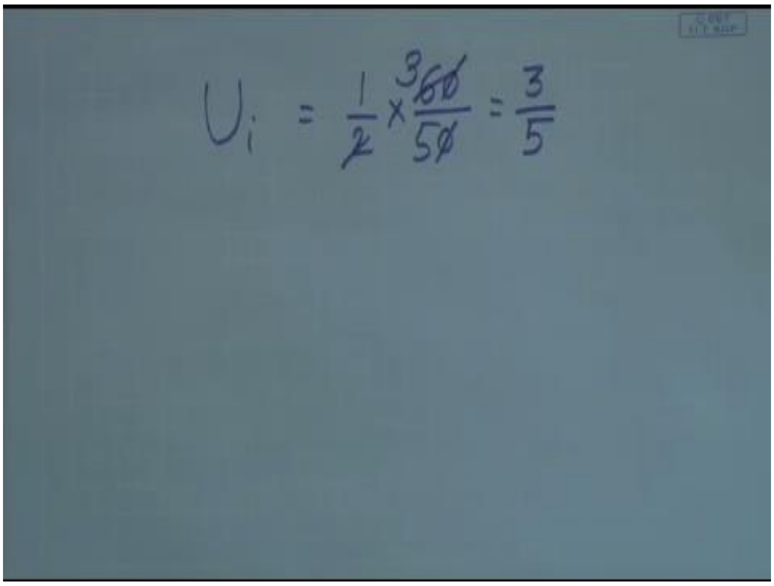

$$U_i = \frac{1}{2} \times \frac{60}{50} = \frac{3}{5}$$

The value of U_i comes out to be $\frac{3}{5}$. So, we have solved for U_v. We have solved for U_s and we have solved for U_i and this is the way in a very simple process, we can solve for gearbox ratios corresponding to particular cutting conditions, particular number of teeth and particular feed conditions. Speed feed, number of teeth given these things, we can easily find out the numerical values of the gearbox ratios that should exist.

So, if time permits, we will also take up other numerical problems of this type so that you will be quite conversant of how to set up fellow's gear shapers in order to make them work properly.

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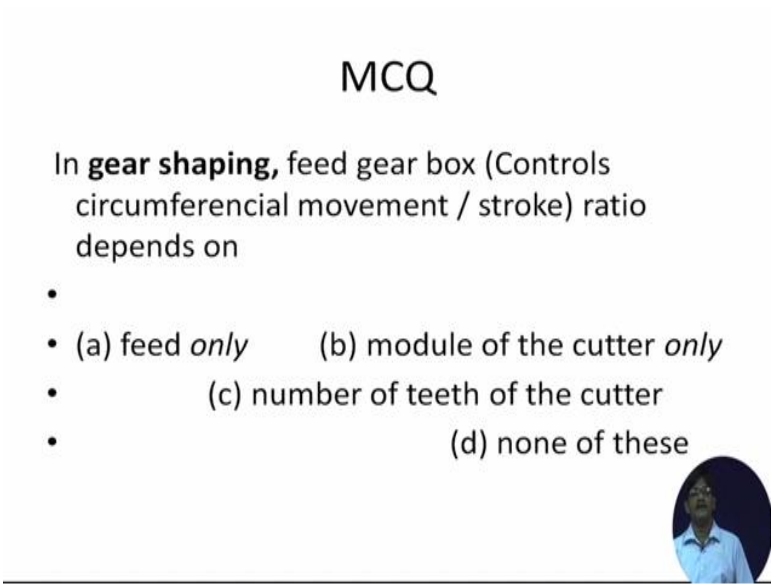

Next, let us now take up a number of multiple choice questions which will help us in learning more about gear shaping. To start with, in gear shaping, feed gearbox controls, in brackets I have put the function of the feed gearbox. So, in case, some person cannot recall it exactly in the exam hall, in gear shaping feed gearbox which controls circumferential movement per stroke that ratio, I mean feed gearbox ratio depends on. Feed only, module of the cutter only, number of teeth of the cutter, none of these.

Now, let us take the options one by one. Feed gearbox depends on the feed only. Now, first of all you say, feed gearbox, what was the expression? So, let us quickly recall the expression. It was something like this.

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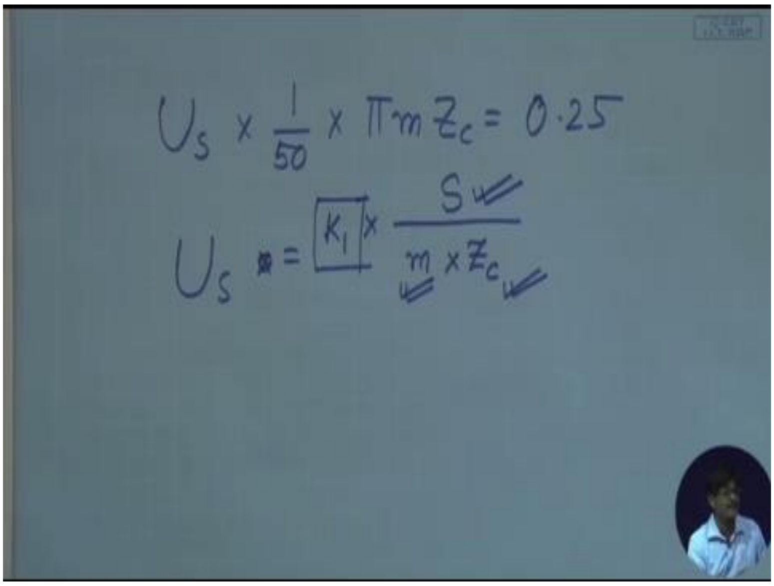

$$U_s \times \frac{1}{50} \times \pi m Z_c = 0.25$$

Now, let us generalise it.

U_s equal to, we will put this as a constant, we are generalising it so, it comes as a constant and let us take it already to that side. So, it is equal to K_1 multiplied by π, π is also a constant. So, let us say that K_1 gulps down π and gulps down this, collectively we are writing K_1. So, what else is there? m goes down, number of cutter teeth that goes down and this we generalise as the feed we can call it F or we can call it S. Let us call it S.

$$U_s = K_1 \times \frac{S}{m \times Z_c}$$

So, we find that the feed gearbox ultimately depends upon some machine constants and it depends upon the feed specified, the module and the number of teeth on the cutter.

It depends on these things and now, let us come back to the problem. So, first option, feed only that is not correct, because apart from feed, we have just now noticed it depends upon the module and it depends upon the number of teeth on the cutter. So, this is definitely not correct. Feed only is definitely not correct. Module of the cutter only; definitely not because it depends upon the feed specified and also the number of teeth on the cutter. The third option, number of teeth of the cutter.

Now, the moment you will notice that only is not mentioned. you have to accept this as correct. Yes, it definitely depends on the number of teeth of the cutter. You might say, but it also depends upon other things. It is fully correct because it is simply stating that it depends upon number of teeth whether it depends upon something else is not our bother issue. This is correct. Yes, it does depend upon the number of feet.

So, this one is correct and therefore, naturally none of these is not correct. So, the correct option here is C. Now, here when you deal with multiple choice questions of this type, the moment you come across only you have to become very alert because you might find that yes, it depends upon the feed which we have stated 0.25 in this particular numerical problem and therefore it depends.

But if you come across this ‘only’, be very alert. Does it only depend upon the feed? You have to ask yourselves. So, whenever you have ‘only’, be cautious.

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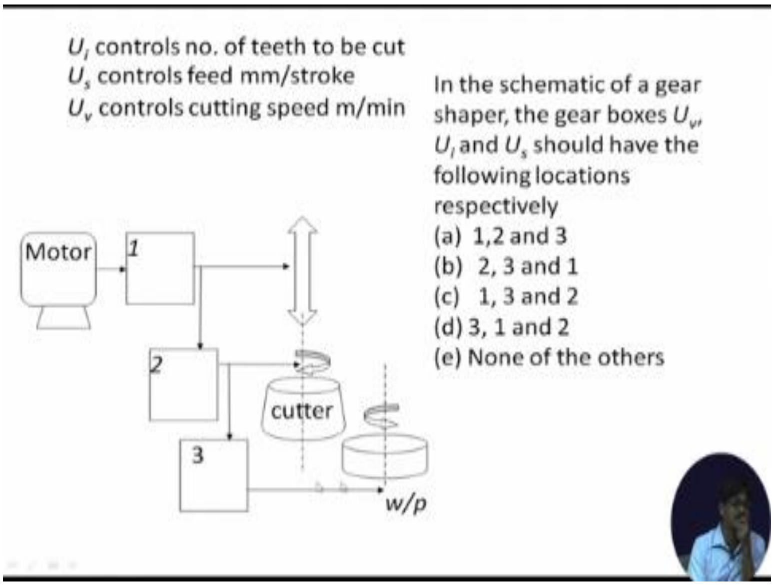

Next problem: what is this problem? This problem after learning so much and discussing so much about fellow gear shaper; it should be extremely simple for you. First of all, we have stated that U_i controls the number of teeth to be cut. U_s controls feed in millimetres per stroke. U_v controls the cutting speed in metres per minute. I have just jumbled it up.

You already know this thing very well. So, what is the question? The question is in this schematic of a gear shaper, the gearboxes U_v, U_i and U_s, mind you U_i has been placed in the middle, should have the following locations respectively? So, first option is that 1 should be U_v, 2 should be U_i and 3 should be U_s. Second option that 2 should be U_v, 3 should be U_i and 1 should be U_s. C is: 1 should be U_v, 3 should be U_i and 2 should be U_s.

Fourth one, 3 should be U_v; 1 should be U_i and 2 should be U_s and 'e' is none of the others. So, we know after so much discussion that without any exception, this one should be U_v; this one should be U_s and this one should be U_i and hence option C is correct in this case.

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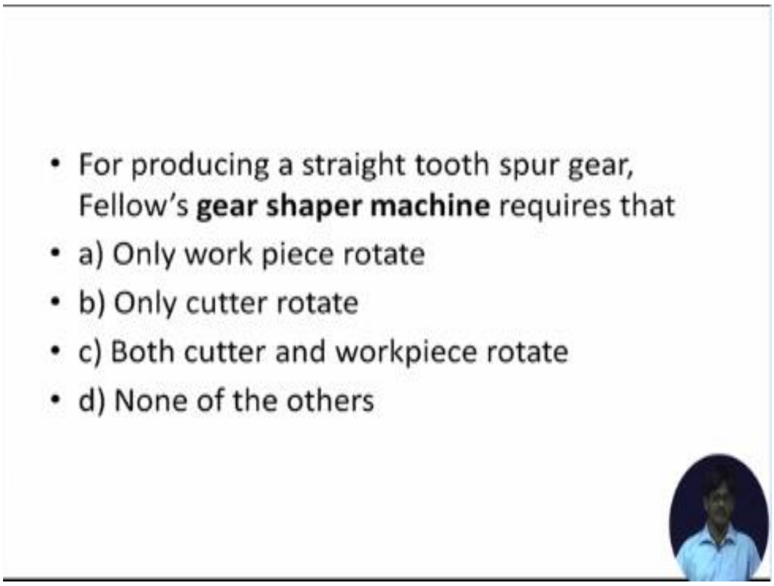

For producing a straight tooth spur gear, fellow's gear shaper requires that only work piece rotate; only cutter rotate; both cutter and work piece rotate; none of the others. So, which one is correct? Only the work piece rotate, but the basic condition which has to be satisfied in case of gear shaping is that both the work piece and the cutter should rotate as if they are rolling against each other as finished gears.

So, only work piece rotate is not possible. In the same manner, only cutter rotate is not possible. Both cutter and work piece rotate is correct. None of the others is therefore not applicable. So, hence here, the correct answer is C, both cutter and work piece rotate.

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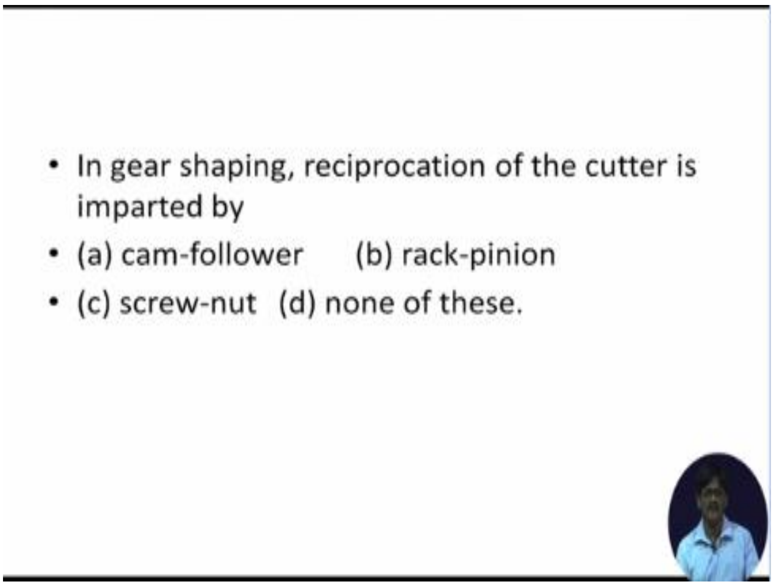

In gear shaping, reciprocation of the cutter is imparted by cam follower; rack and pinion; screw nut; none of these. So, in order to find out this answer, I will just introduce what they exactly mean. Some of them; you are already conversant with. What is cam follower?

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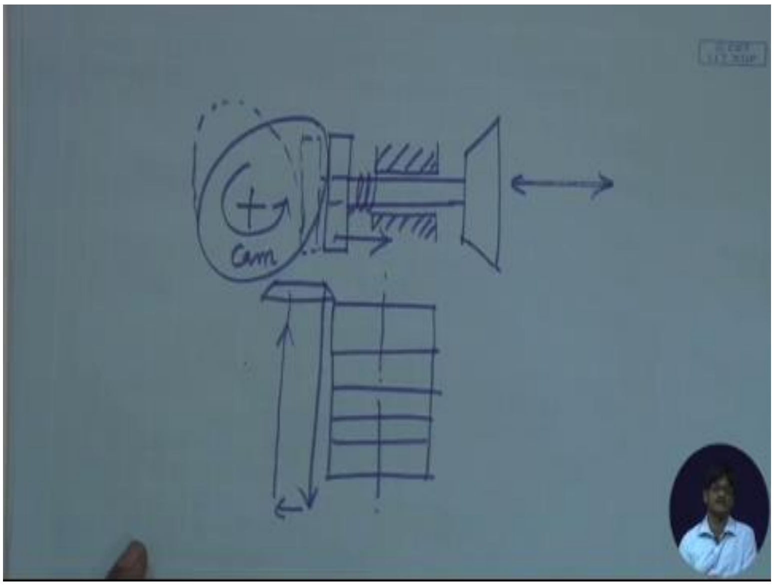

Cam follower can be something very simple of this type. Suppose, this is what we call as the disc cam and this is its centre of rotation. So, you can very well understand that it is having a non-circular profile a load structure and therefore, it is going to push this body outwards. If it is having a guide way, if it is passing through guides, it is going to push it outwards and if it is spring loaded, if there is a compression spring, this is going to come back when this rotates and say takes up some position of this type like that.

So, if this rotates continuously, this is going to execute reciprocation. Question is: do we have that kind of a mechanism for imparting the reciprocating action? No. Why not? Because in this case generally, the problem is the stroke is not quite adjustable. If you want to change the stroke length, it is difficult. So, generally, we go for crank connecting rod mechanism where it is easy to change that.

Now, why do we need to change the stroke in case of gears? That is because the width of gear which is being cut, it might differ from case to case or you might be cutting a stack of gears like this. A number of gears in a stack can be cut by a single stroke of the cutters, up down. And gear number 1, 2, 3, 4 together can be cut. So, this stroke length is very frequently has to be changed.

So, cam and follower is out, but interestingly cam and follower is used in this particular machine for the small amount of relieving motion which is required when the cutter goes up; the cutter goes down the cutter relieves itself and again moves up. This small motion can be realised by the help of a cam follower device. So, coming back to the question, we have cam follower. No. Rack and pinion.

Rack and pinion is able to produce reciprocation but the problem is that there are other many much more easier methods by which we can have reciprocation because if you use rack and pinion, you have to have yet another device by the help of which reciprocation will be obtained. Rack and pinion can only change rotation to straight line movement, but it cannot bring about reciprocation.

So, that is why it is not a good choice. Screw nut mechanism. Screw nut mechanism is also not used and therefore, none of these is the correct answer. You might say that why is screw nut not used. Screw nut mechanism is not used because the screw will have to rotate very fast inside the nut and lot of sliding wear will take place unnecessarily. There are so many other easier options to obtain reciprocatory motion.

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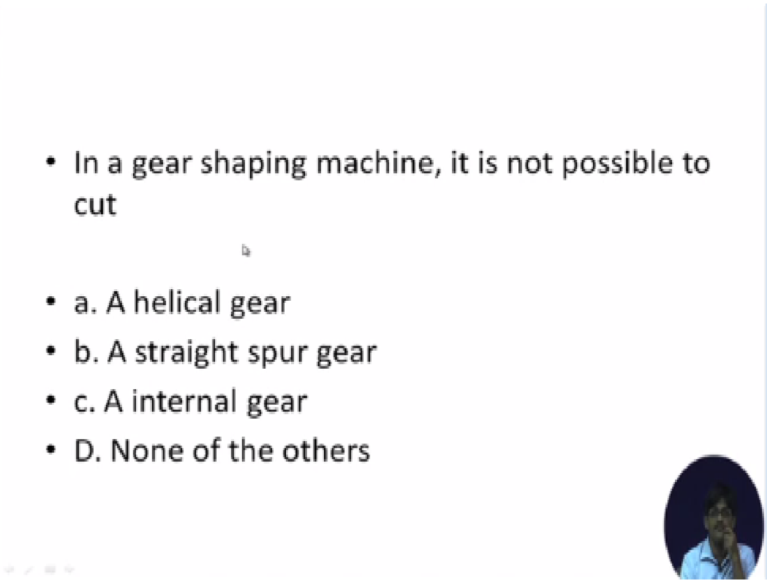

And also, screw and nut will not be able to give you the reciprocation. You have to have another mechanism or you have to have another type of controls which will give you reciprocation. Screw and nut can only bring about rotation to linear motion that is not reciprocation. In a gear shaping machine, it is not possible to cut a helical gear, a straight spur gear an internal gear; none of the others.

So, first of all, helical gear. Helical gears can be cut on shaping machines, though not as simply or elegantly as on the hobbing machine. The hobbing machine can cut helical gears by a very simple procedure. In gear shaping machines, either we have to have a mechanical guide way which will make the cutter move in a helical manner or we have to have some sort of computer control.

So, it is possible to cut a helical gear. Next option as straight spur gear. In a gear shaping machine, straight spur gear is the obvious thing which can be cut. So, this is not correct. An internal gear. Internal gear can be cut. So, none of the others is the correct answer.

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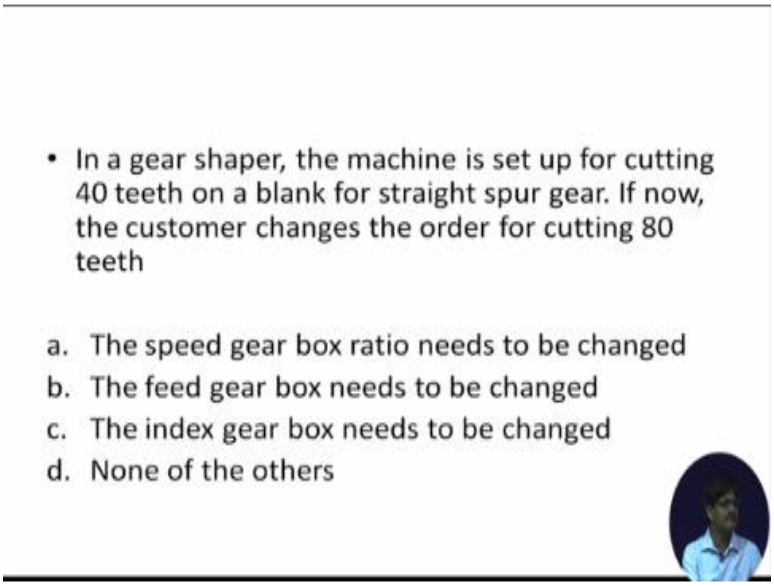

In a gear shaper, the machine is set up for cutting 40 teeth on a blank for straight spur gear. If now the customer changes the order for cutting 80 teeth. I have set up the machine for cutting 40 teeth and suddenly, the customer comes and says that no I want 80 teeth. So, the options are: the speed gearbox ratio needs to be changed; the feed gearbox needs to be changed; the index gearbox needs to be changed and none of the others.

The speed gearbox needs to be changed. Why? We are not changing the speed. If I am cutting a 80 teeth gear instead of 40 teeth gear, why do I really need to change the speed? No; not at all. So, the first option is not correct. Second one, the feed gearbox needs to be changed. Am I changing the feed? Do I need to change the feed? Not really, feed is going to define the surface finish and the customer has not stated that he wants to change the surface finish. No; not at all.

So, we still have no need to change the feed gearbox. The third option, the index gearbox needs to be changed. This is correct. Yes, the index gearbox needs to be changed so that we can accommodate the 80 teeth gear and have the proper RPM ratio between the cutter and the work piece so, that the 80 teeth gear is cut correctly with correct geometry.

So, option C is correct and therefore; naturally none of the others is not applicable. So, the index gearbox needs to be changed.

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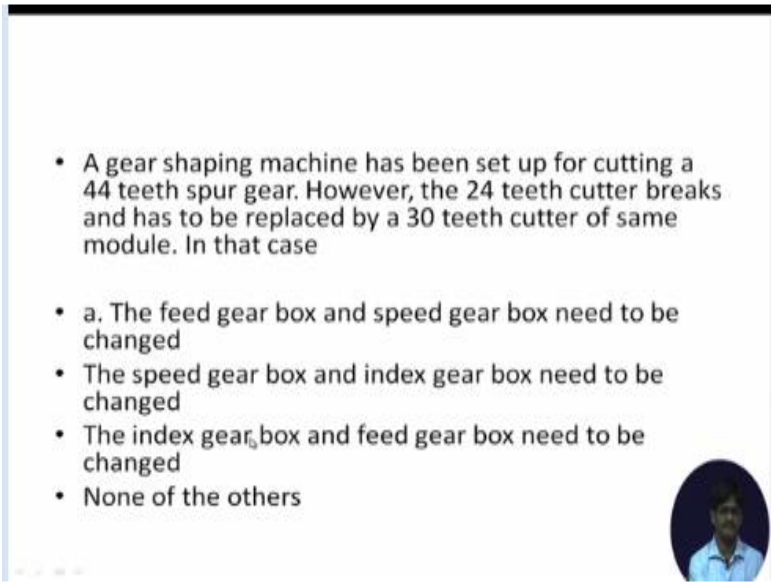

A gear shaping machine has been set up for cutting a 44 teeth spur gear. However, the 24 teeth cutter breaks; I mean it is damaged, it is gone. And has to be replaced by a 30 teeth cutter of same module. In that case, the feed gearbox and the speed gearbox needs to be changed. The speed gearbox and the index gearbox needs to be changed. Third option, the index gearbox and the feed gearbox need to be changed. None of the others.

So, let us see, if my cutter number of teeth is changing, what are the things that need to be changed? First of all, once the machine has been set for 44 teeth to be cut on a spur gear then U_i must have been set with respect to the ratio of the numbers of teeth on the cutter and the work piece. Therefore, U_i will definitely get changed. Second, if the number of teeth of the cutter is changed, we have previously learned that U_s will change.

Why? Because, as we learned that U_s is equal to a constant multiplied by module and also, the number of teeth on the cutter and it depends upon the specified feed. It depends upon the module of the cutter and also it depends on the number of teeth on the cutter. Therefore, as the number of teeth is changing we will definitely have a change in U_s.

So, the answer should be the index gearbox and the feed gearbox need to be changed. So, the third option is correct. Let us see, do we have any other options?

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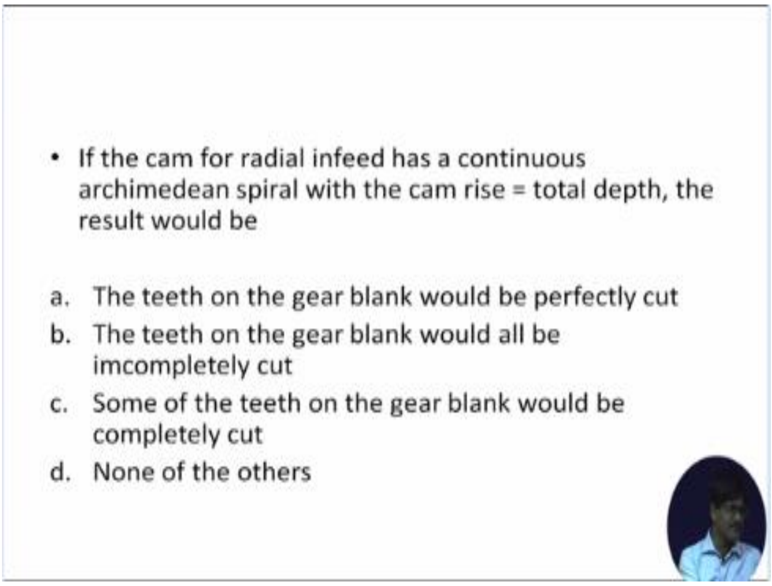

We can take another one. If the cam for radial infeed has a continuous Archimedean spiral with the cam rise is equal to total depth. The result would be the teeth on the gear blank would be perfectly cut. The teeth on the gear blank would all be incompletely cut. Some of the teeth on the gear blank would be completely cut. Now, what is that? The second option and the third option are they different?

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And third option is quite tricky. So, let us take them one by one. The teeth on the gear blank would be perfectly cut. No, absolutely wrong. Because if you are having an Archimedean spiral continuously rising from the beginning right up to the end. That means the depth is continuously increasing and there is no teeth which is going to have the correct depth because the correct depth will only be reached at the very end where total depth is achieved.

So, teeth in the gear blank would not be perfectly cut. Second option, the teeth on the gear blank would all be incompletely cut. This seems to be correct. Yes, would all be incompletely cut; maybe only the last one that also for an instant only. It will be having the correct depth.

Some of the teeth on the gear blank would be completely cut. What does this mean? It means some of them would be completely cut.

No, if you are having continuous Archimedean spiral basically, the difference is that you are nullifying the idle period or the dwell period of the cam during which it distributes the complete cut that means the total depth for all the teeth. For all the teeth, the cam remains at a particular position. There is no further radial infeed. Total depth has been achieved and it simply goes on cutting.

So, that each and every teeth have correct depth. Therefore, option B is correct and naturally, none of the; others is not applicable. So, with this, we come to the end of the 14th lecture. We will take up other subjects in the subsequent lectures. Thank you very much.