Spur and Helical Gear Cutting
Prof. Asimava Roy Choudhury
Department of Mechanical Engineering
Indian Institute of Technology – Kharagpur

Lecture – 38
Gear Hobbing - IV

Welcome viewers to the 18th lecture of the course spur and helical gear cutting. So, up till now we have discussed a problem in which a helical gear has been cut on the gear hobbing machine and for that we have had a look at the ratios of the gearboxes that are supposed to allow us to cut that particular gear. And we have found out the values of speed gearbox, feed gearbox, index gearbox and lead change gearboxes.

Now, still it leaves behind some questions that are yet unanswered and we will have some look at some of these questions.

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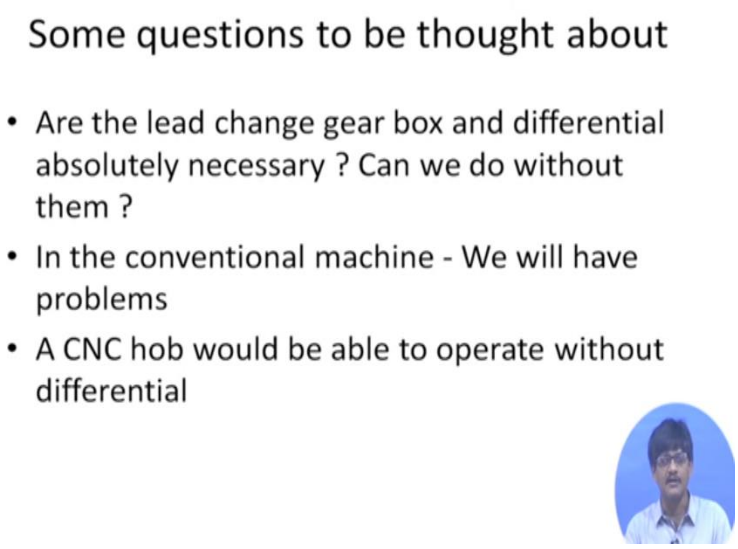

First of all, are the lead change gearbox and differential absolutely necessary? Can we do without them? Because up till now, when we were cutting spur gears, why should there be in the first place an extra gearbox and differential? Why not the same thing can be used? So, we have to justify why we are doing this in the first place?

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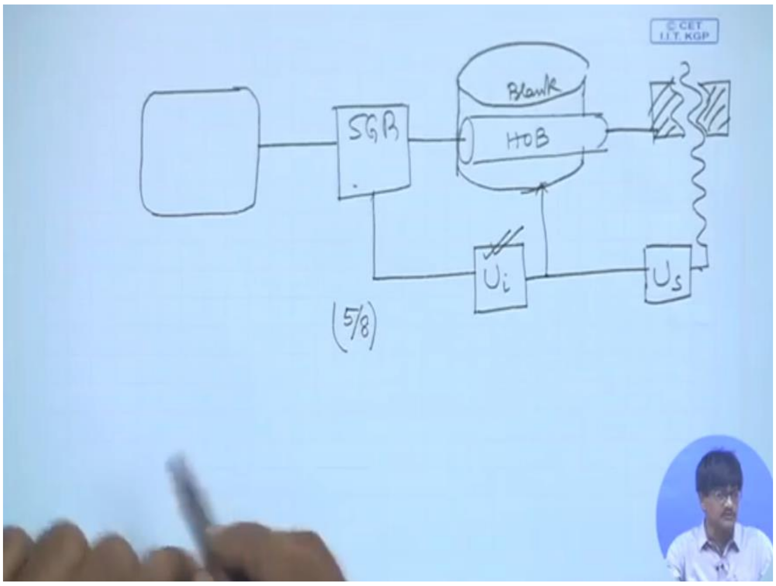

For that, let us have a quick look at the setup. What does the setup consist of? Once again there is the motor, we have the speed gearbox and from there we are having hob rotation. From there, we are having differential, suppose I intend not to use the differential. In that case, what should be my setup? I should have U_i here. I should rotate the, let us try it this way. That is it.

Blank and of course U_s will be appearing here. That part we are not concerned with at this moment. This is our setup. Now, if we do not intend to use the differential here, how can we solve the problem? We can say this way that if we are cutting a particular number of teeth for spur gear. We can definitely find out U_i and it comes to be a simple gear ratio very easy to implement.

Previously, it came to be $\frac{5}{8}$. Now that is quite simple in order to achieve $\frac{5}{8}$. Let us quickly have a look. How much did we? How did we achieve that?

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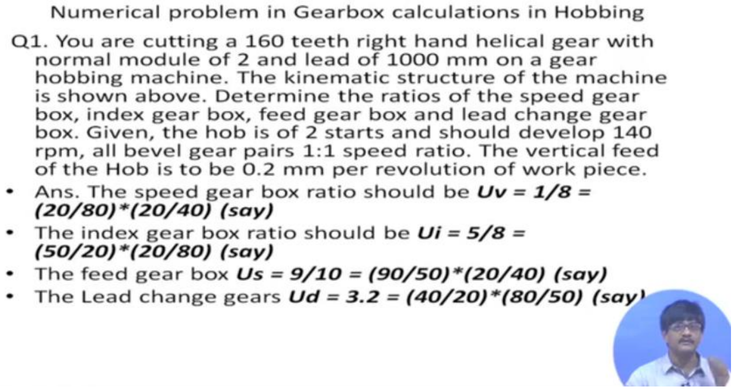

If you look at it, $\frac{5}{8}$ was obtained by $\frac{5}{20} \times \frac{20}{80}$. In one stage, you could have also had $\frac{50}{80}$, in order to get $\frac{5}{8}$, so it is not a problem at all. But suppose,

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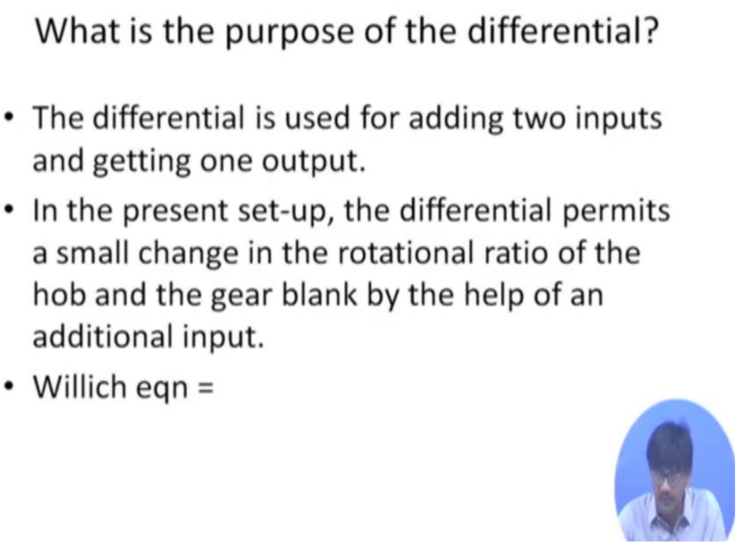

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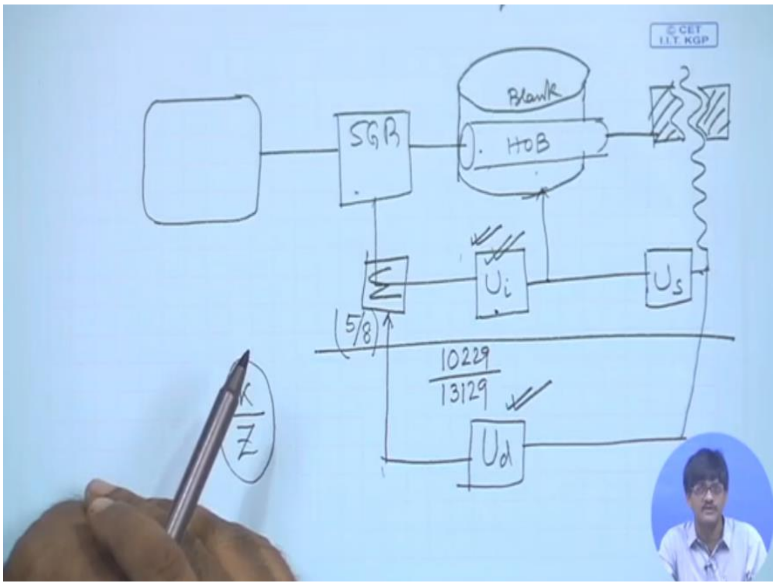

Instead of that, we have this particular problem that cut a spur gear of the same number of teeth with a particular helix angle. We can redefine U_i, so that instead of having the ratio $\frac{K}{Z}$. It will have a slightly changed value of this particular ratio. So, you can have that but the simple problem is, if you have of such a particular relation you will find that U_i comes out to be very very difficult to get.

It might be some number which is very large say 10229 ÷ say 13129 etc and they are prime to each other. And therefore, you have to have some particular number of teeth in order to achieve that. I intend to introduce a numerical problem in the multiple choice question series. So, this thing will be made clear. So, at this moment I do not want to discuss it.

I first want to give you one numerical problem and there you can actually solve it and see how this particular problem is appearing? But it is absolutely clear that you might avoid the differential and just adjust this U_i value in order, to get a value slightly shifted from $\frac{K}{Z}$. At this moment $\frac{K}{Z}$ decides U_i. But what are the advantages of using differential? One advantage is this that the gear ratio is simple for U_i.

But you are spending more money in order to get lead change gears and the differential what advantage does it give? The advantage is this that, if you have to change the number of teeth, keeping the helix angle the same. You have to make very simple changes in U_i and if you want to change helix angle, if the differential line is present.

You just have to touch U_d. If you want to change helix angle, you change U d, if you want to change number of teeth, you change U_i in this particular setup. But if you do not have it, in that case if you want to change the number of teeth, you have to make some complex change in U_i.

If you want to change the helix angle, you have to make some complex change in U_i etc. This becomes a gearbox which is going to control 2 things at the same time. So, this is the advantage of using the differential. Now, is the differential absolutely necessary? Well, if you have a machine which is controlled by CNC. In that case, instead of drawing power for all the operations from the same motor, you can have individual motors.

Dedicated to blank rotation, dedicated to hob rotation, dedicated to hob vertical motion. So, individual motors taking care of all these will remove all the gearboxes and differentials etc. Because those motion changes now can be achieved by CNC. Then why do not we go for CNC? Why are we studying all these things? Because CNC invariably brings in power supplies and their computer control etc.

And they are likely to be more costly. This sort of conventional machines, if you are having some set numbers of teeth, set helix angles, etc., to be cut. In that case, ultimately, computer control might come out to be too much cost for too few things to achieve. It might be superfluous, it might be redundant. So, this sort of setup in hobbing even though it is conventional, even though it is using gearboxes.

Still, it can permit us to do many things, many numbers of teeth, helix angles etc., even surfaces which are permissible by the method of generation even if they are not gears, those profiles can be cut. I intend to show you one example in which the T crushing rollers which are used those particular profiles we had been able to produce on the gear hobbing machine which are actually produced by turning and milling in ordinary cases.

I will just veer off from here and show you such a setup. First of all the profile which was to be made we made a simulation just like the previous case. **(Video Starts: 10:23)** This was the T roller profile and we made a simulation to find out what sort of cutters we would require in order to get? So, the cutter profile is rolling and ultimately its conjugate envelop is producing the particular profile to be cut.

So, this way once you have this, we went for the cutting. And you can see on the hobbing machine, this is the prototype of the disc which we have taken to represent the T roller. This is a fly cutting hob. Instead of a hobbing cutter, you are using a fly cutting hob and it is cutting teeth all around. It cuts from the top to the bottom. It is having a helix angle and is having a particular profile and that is being provided by the fly cutter hob.

Fly cutter hob typically, means a single tooth cutter which is generally done for starting, experimenting and for unconventional profiles, etc. So, once this was done towards the end this is the profile which was getting generated, the T crushing roller profile. So, we showed that it can well be done by generation process but we did not pursue it much because ultimately we understood that CNC would be the best option to cut these if we included the full variety of such cutters.

(Video Ends: 12:15) So, now that we are convinced let us come back to the previous discussion.

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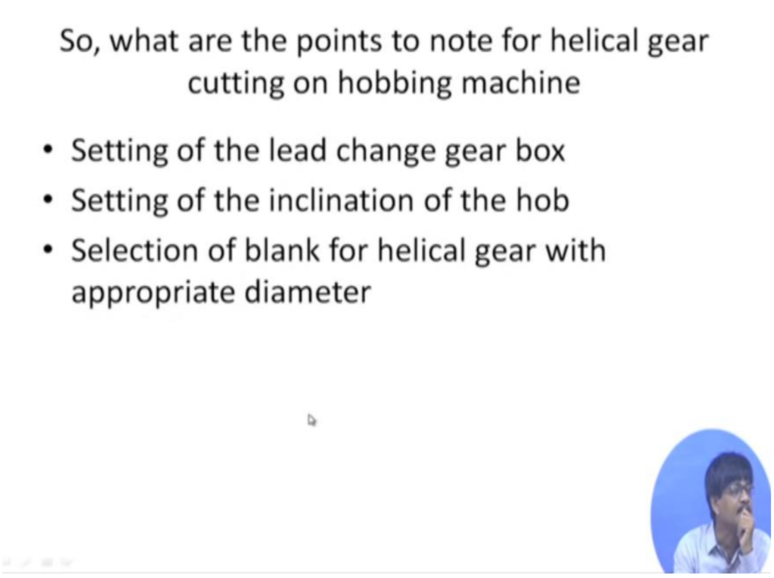

So, what are the things that we need to do when we are cutting a helical gear on the hobbing machine, mainly 3 things. One is setting the lead change gearbox, which we have already seen from the calculations, setting of the inclination of the hob. If you remember, let me remind you, when we were working on the milling machine cutting a helical gear that table had to be swivel about a vertical axis.

In order, to give an inclination and why was this inclination given? Because we said that even if we give motion to the cutter in the direction of the helix to be cut, the cutter itself has to be oriented in the direction of motion, so that it follows through the cut in the same direction. So, the inclination of the hob also has to be given for the same reason. So, that even if it is cutting the helical groove perfectly. It as a physical body has to be oriented in that direction.

So, we will find that the hob is given different inclinations for cutting different jobs. For example, right hand threads, left hand threads, spur gears, in each case their hob is given different inclinations. So, that has to be taken care of and selection of blank for helical gear with appropriate diameters. When we are cutting a helical gear of a particular number of teeth and a normal module.

We have to calculate the outer diameter and accordingly select the particular blank size, which will be having the correct outside diameter.

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Why not make everything computer controlled ?

- What will go out ?
- The gearboxes, the differential mechanism

All these things we will definitely discuss. This we have already discussed that we do not make everything computer controlled, though it has its advantages because, though gearboxes and differential mechanisms will go out. It has to bring in more motors and control systems etc. which might make it ultimately more costly. And it will achieve something which it is already achievable by the conventional system. But CNC machines are coming in a big way.

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- In gear cutting, differential indexing is resorted to (in place of simple indexing) when
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- Gears are cut on the Hobbing machine
- Higher accuracy of gear tooth profile is required
- Hard, tough materials are being machinined
- Even number of teeth are being cut
- Odd number of teeth are being cut
- None of the others
-

So, it is a general discussion in gear cutting, differential indexing is resorted to, in the place of simple indexing. This we start a number of multiple choice questions which are linked to this differential indexing and differential gears etc. So, differential indexing is resorted to, in place of simple indexing when gears are cut on the hobbing machine. Higher accuracy of gear tooth profile is required, hard tough materials are being machined, even number of teeth are being cut, odd number of teeth have been cut, none of the others.

We resort to differential indexing in place of simple indexing when gears are cut on the hobbing machine. No, gears are cut on the hobbing machine by continuous indexing. The differential indexing that we are referring to here does not refer to the differential gearbox. No, it is slightly different we have studied about differential indexing in case of milling.

So, do we require differential gearbox have a higher accuracy of gear to profile? No, not exactly we require differential indexing when simple indexing cannot provide us with the particular amount of rotation which is required in between the cutting of gear teeth. So, hard and tough materials are being machined. No, even number of teeth are being cut. No, odd number of teeth are being cut.

Here, I think we should design these particular options a little more alert manner. Because odd number of teeth have been cut, this might be allowing some of the options to be taken. So, best is we will say here is answer is none of the others. Differential indexing is resorted to, when the amount of rotation required from moving from one to another is not available in case of simple indexing.

And even number of teeth are being cut, odd number of teeth are being cut. When I give you one question? I think I will remove these options. Because they might be true in one case that is the differential indexing is being done, an odd number of teeth are being cut, so it is true. So, these 2 options should be removed in order to make the question well posed. So, I am sorry, I am taking away those 2 options and then the answer is none of the others.

So, even number and odd number these 2 options, I am removing from consideration.

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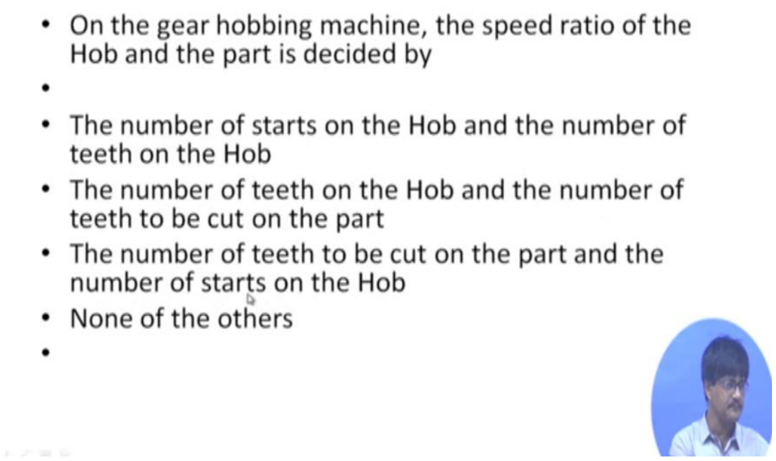

So, on the gear hobbing machine, the speed ratio of the hob and the part is decided by? This is interesting. On the gear hobbing machine, how do we decide the speed ratio of the hob and the part. We know that the speed ratio of the hob and the part is equal to $\frac{K}{Z}$, where K is the number of starts in the hob and Z is the number of teeth of the part.

So, let us see the first option, the number of starts on the hob and the number of teeth on the hob. This is not correct. Number of teeth on the hob has nothing to do with the number of teeth on the part. Number of teeth on the hob they are provided in order to give cutting action to the worm which is replaced by the hob. Number of teeth on the hob has no relation to the speed ratio.

Next comes, the number of teeth on the hob and the number of teeth to be cut on the part. Number of teeth on the hob once again, it has nothing to do with this. So, first option and second option both are incorrect. The number of teeth to be cut on the part and a number of starts on the hob. This is correct. $\frac{K}{Z}$, number of starts is K and Z is the number of teeth to be cut on the part. So, 3 is correct among these options.

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- In gear hobbing RPM of the gear blank depends on
- (a) RPM of the hob cutter
- (b) number of teeth of the gear blank only
- (c) diameter of the hob cutter only
- (d) none of these.

Next, in gear hobbing RPM of the gear blank depends upon? RPM of the hob cutter, number of teeth of the gear blank only, diameter of the hob cutter only, none of these. So, let us see, in gear hobbing, RPM of the gear blank. Now, what does the RPM of the gear blank depend upon?

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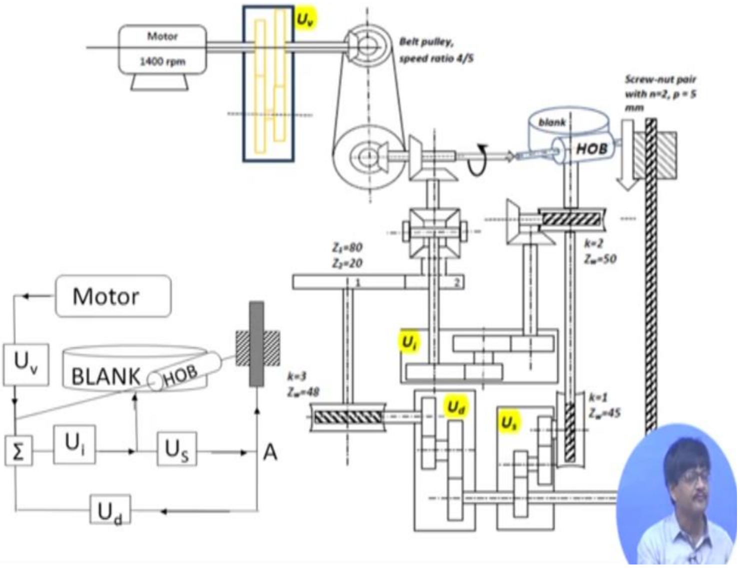

So, let us quickly have a look at the main figure once again. Rotation of the blank, what does it depend upon? Rotation of the blank essentially depends upon once again $\frac{K}{Z}$.

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- In gear hobbing RPM of the gear blank depends on
- (a) RPM of the hob cutter
- (b) number of teeth of the gear blank only
- (c) diameter of the hob cutter only
- (d) none of these.

So, $\frac{K}{Z}$ let us see, what are the options present, RPM of the gear blank. So, does it depend upon RPM of the hob cutter. If the RPM of the hob cutter is provided, the gear blank RPM will depend upon it, yes. Number of teeth of the gear blank only. Now, let us see, let us take a case suppose the gear blank is having 40 teeth. Will the RPM of the gear blank depend only upon 40?

No, because it since if it depends upon the ratio $\frac{K}{Z}$, definitely it will depend upon K and not only K.

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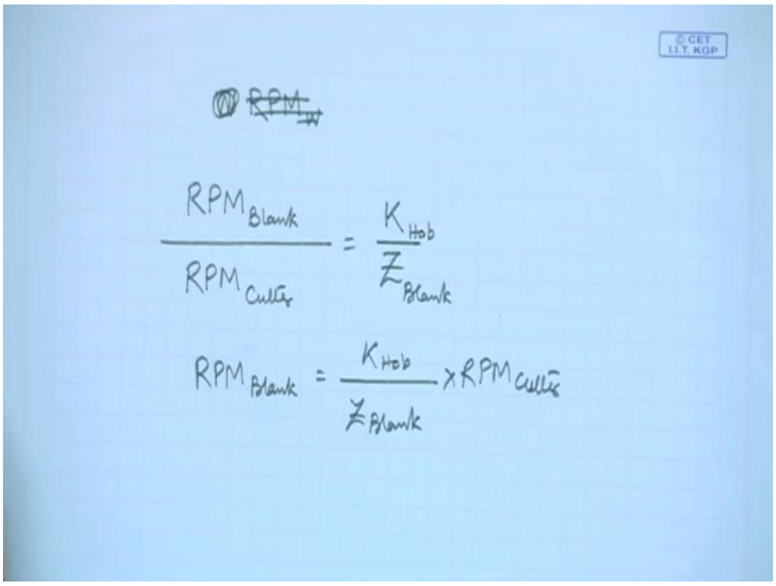

Since, let us, write this down RPM work piece, or we have used the term blank. So, let me cut this:

$$\frac{RPM_{blank}}{RPM_{cutter}} = \frac{K_{hob}}{Z_{blank}}$$

$$RPM_{blank} = \frac{K_{hob}}{Z_{blank}} \times RPM_{cutter}$$

Once, we have established this it becomes extremely simple.

So, if we go to the screen once again, RPM of the cutter is appearing here, it depends upon RPM of cutter. Second is, number of teeth of the gear blank only. Is number of teeth here? Yes, number of teeth here. But there is the word only and we were supposed to be very alert on this therefore, second option is not correct.

Now, let us see the third option. Diameter of the hob cutter only. Now, where is diameter of the hob cutter coming in? So, this option is also not correct. None of these. So, the answer to this question is the first option. We come to the conclusion that in gear hobbing RPM of the gear blank depends upon RPM of the hob cutter first option is correct.

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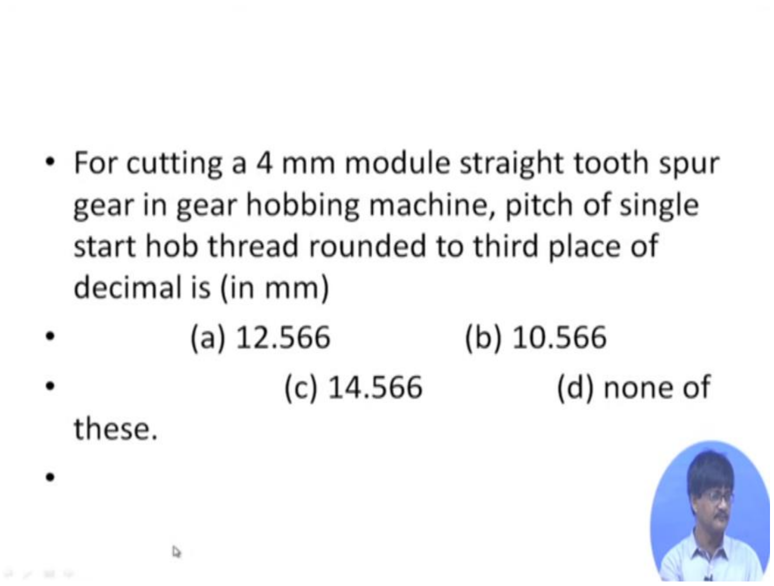

Now, for cutting a 4 millimeter module straight to spur gear in gear hobbing machine, pitch of single start hob thread rounded to third place of decimal is? There are 4 options given. Now, what is exactly meant by this question? I am trying to cut, a straight tooth spur gear. Now for cutting this straight tooth spur gear, how much is the module of that it is having 4 millimeters module and using a gear hobbing machine.

So, the pitch of the single start hop thread rounded to third place of decimal has to be found out. Now, for that let us draw a figure first of all.

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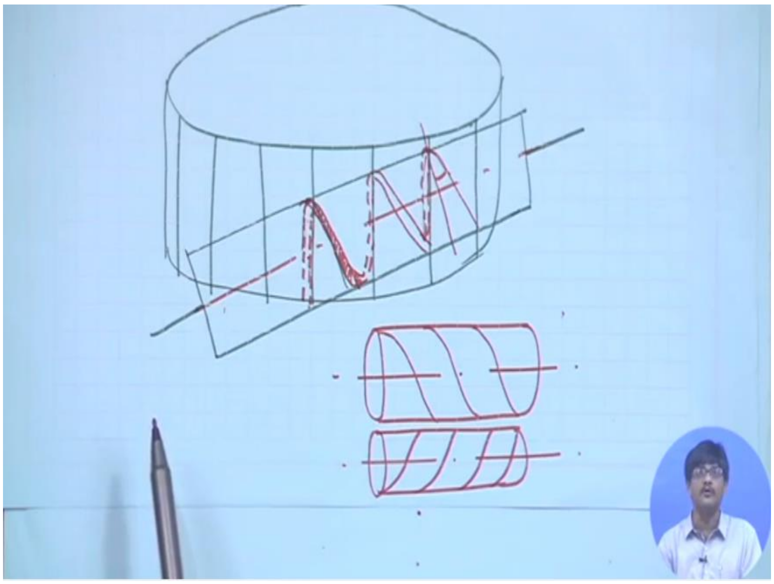

This figure will explain a number of things which we have discussed up till now. If we are cutting straight spur gear teeth and a particular hob cutter is in contact with it, say this is the hob cutter. First thing that we should notice is that the hob cutter is inclined. When we are having ordinary worm and worm gear mechanism pairs the worm is not inclined. Why? Because the worm gear teeth they are slightly inclined they are inclined at the helix angle.

But here we have to cut this gear which is having straight spur gear teeth. So, in that case, the helix angle, suppose the helix angle of the teeth they are such let me use a different colour. If this be the helix angle, on the other side it matches with the direction of the spur teeth like this. So, this is the thread of the worm and this is the side that I can see. I can see this side, this thread.

The thread which I cannot see of the worm is on the other side and it is in connection with the teeth of the spur gear. And therefore, it must be having this particular inclination which is matching with this spur gear. Therefore, once again, if we have a look, this particular worm must be having an inclination which makes its thread match with the teeth of the spur gear in the place of contact between the 2.

And therefore, it simply means that I must have rotated it, by, if this be the helix angle. It is a screw thread, if we say that this is the helix angle, I must have rotated this by the helix angle in order to get this inclined in this particular direction. So, now, first of all, if I am cutting a helical thread so, in that case, we first have to find what is the hand of the helix?

So, when we are talking about the hand of the helix, the hob can have a hand of the helix. This worm gear can have a particular hand of helix. So, first of all, when we are looking at a threaded element, this is one hand and this is another hand of helix. So, this one is right hand and this one is left hand, so there must be a way in which it can be properly defined.

So, when we are taking a right hand hob and we are cutting a left hand, so there can be different combination first of all, 6 combinations are so. When I am taking a right hand hob cutter and cutting a straight spur gear. When I am using a left hand hob cutter and cutting a straight spur gear. When I am having a right hand hob and cutting left hand helical gear and vice versa. So, so many cases are there.

And in each case, we find that ultimately at the place of contact, the inclination of the thread of the hob has to match with the inclination of the teeth at that particular position. So, now that the time is almost near the end for this particular lecture, we will take this one in detail in the next lecture, first of all hand of the helix and how to decide upon the inclination of the hob in each of these combinations. Thank you very much.