NPTEL

NPTEL ONLINE CERTIFICATION COURSE

Course on
Spur and Helical Gear Cutting

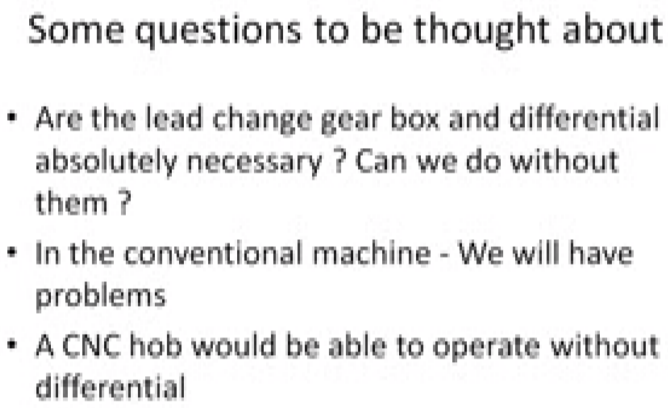
by
Prof. Asimava Roy Choudhury
Department of Mechanical Engineering
IIT Kharagpur
Spur and helical gear cutting
18th Lecture

A. Roy Choudhury

Professor, Mechanical Engineering Department
IIT Kharagpur

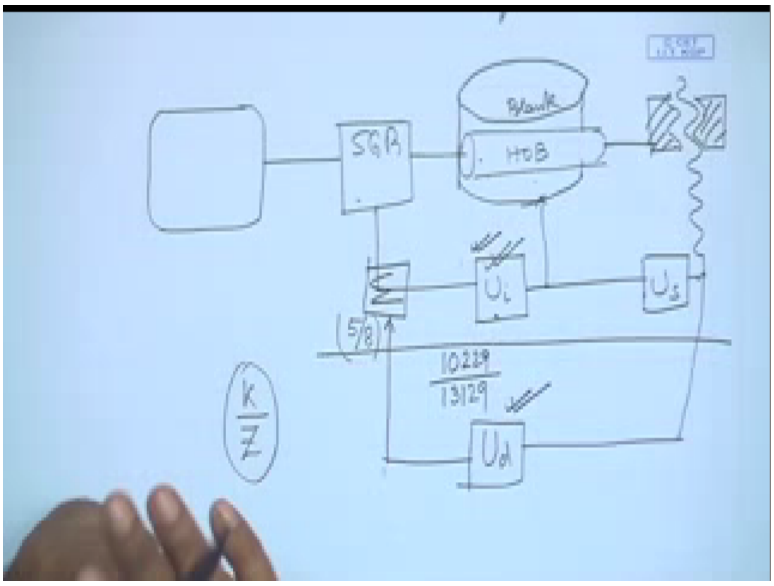
Welcome viewers to the 18th lecture of the course spar and helical gear cutting so up till now we have discussed a problem in which you know helical a helical gear has been cut on the gear humming machine and for that we have had a look at the ratios of the gear boxes that are supposed to you know allow us to cut that particular gear and we have found out the values of speed gear box feed gearbox index gearbox and lead change gearboxes okay.

(Refer Slide Time: 01:13)



Now still it leaves behind some questions that are yet unanswered and we will have some look at some of these questions see first of all are the lead change gearbox and differential absolutely necessary can we do without them because you know up till now when we were cutting spur gears why should there be in the first place and extra what we call it 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.

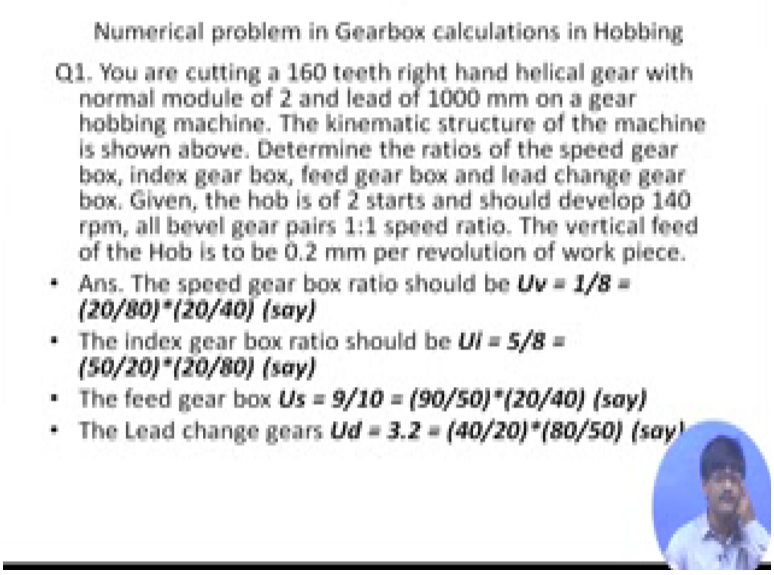
(Refer Slide Time: 01:43)



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 speed gearbox and from there we are having table rotation from there we are having differentials above I intend not to use the differential in that case what should be my setup I should have Ui here okay I should rotate the let us draw it this way that is it blank and of course you us will be appearing here.

That part we are not you know concerned with at this moment this is our setup now if we don't intend to use the differential here how can we solve the problem we can say it this way that if we are cutting a particular number of teeth for spur gear okay we can definitely find out Ui and it comes to be a simple gear ratio very easy to you know implement previously it came to be five by 5/8 now that is quite simple in order to you know achieve 5/8.

(Refer Slide Time: 03:47)



Let us quickly have a look how much did we how, how did we achieve that yeah if you look at it 5/8 was obtained 5/20*20/80 in one stage you could have also had 50/80 in order to get 5/8 so it is not a problem at all but suppose instead of that where were we yeah 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 Ui so that instead of having K/Z instead of having the ratio K/Z okay it will have a slightly changed value of this particular ratio so you can have that but the simple problem is if you have such a particular relation you will find that Ui comes out to be very, very computer money very, very difficult to get it might be some number which is very large say 10299 divided by say 13129 etc and they are trying to each other.

And therefore you have to have some particular number of teeth in order to achieve that okay I intend to introduce a numerical problem okay in the multiple choice question series so this thing will be made clear okay 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 you know clear that you might avoid the differential and just adjust this Ui value in order to get a value slightly shifted from K/Z and this moment K/Z decides Ui.
So but what are the advantages of using differential one advantage is this that the gear ratio is simple for Ui but you are spending more money in order to get lead change gears and the differential what advantage does it give the advantages it is that if you have to change the number of teeth keeping the helix angle the same you only have to make simple changes in Ui you have to make very simple changes in Ui and if you want to change helix angle.

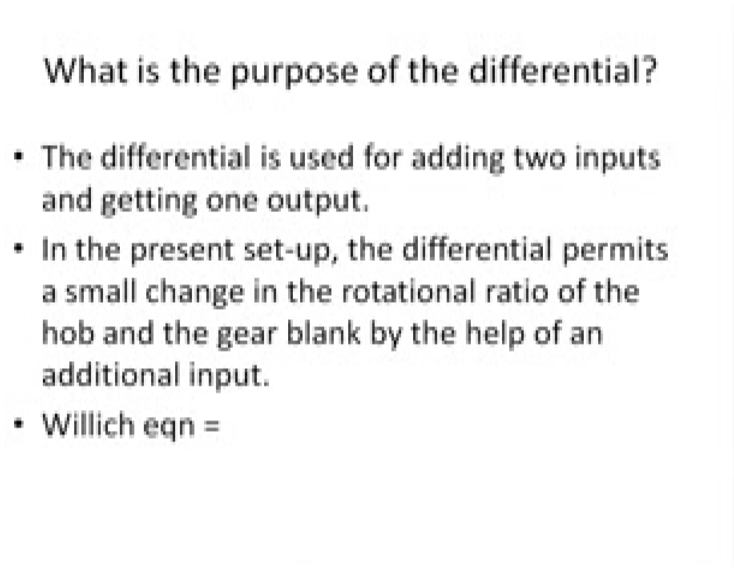
If this thing is present okay if the differential line is present you just have to touch Ud you just have if you change one to change helix angle you change Ud if you want to change number of teeth you change Ui in this particular setup but if you do not have it in that case if you want to change Ui you have to make some complex change in Ui sorry if you want to change the number of teeth you have to make some complex change in Ui if you want to change the helix angle you have to make them complex change in Ui etc.

This becomes you know our gearbox which is going to control two things at the same time okay so this is the advantage of using the differential now is the differential absolutely necessary well if you have you know a machine which is controlled by C and C in that case instead of drawing power for all the operations from the same motors you can have individual motors you know dedicated to blank rotation dedicated to hob rotation dedicated to hub vertical motion.

So individual motors taking care of all these bills removes all the gear boxes and differentials etc because they can be those motion changes now can we achieve by CNC then why do not we go for CNC why are we studying all these things because CNC invariably brings in you know power supplies and their computer control etc and they are likely to be more costly okay this sort of conventional machines if you are having some set numbers of teeth set helix angles etc to be cut okay.

In that case ultimately computer control might come out to be you know too much cost for too few things to achieve it might be superfluous it might be redundant so up so this sort of setup in hobbing okay 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.

(Refer Slide Time: 09:48)



Even and operations which are you know surfaces which are permissible by the method of generation even if they are not gears those, those profiles can be cut I intend to show you one example in which the D rollers three crushing rollers which are used those particular profiles which we had been able to produce on the gear hobbing machine which are actually produced by turning and milling in ordinary cases okay.

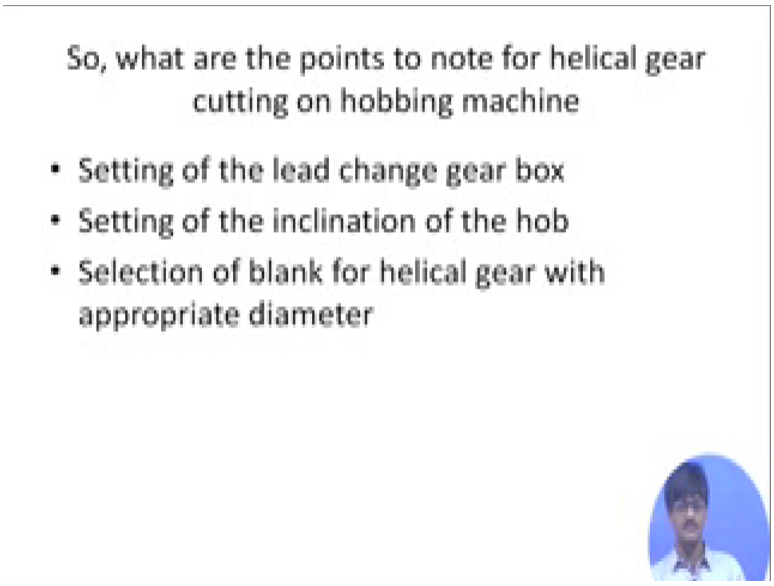
I will just veer off from here and show you such, such a setup just bear with me for a moment first of all the profile which of which was to be made we made a simulation just like the previous case this was the troller profile and we made a simulation to find out what sort of cutters we would require in order to get so the cutter profile is rolling and ultimately it is envelope is the conjugate envelope is producing the particular profile to be cut okay.

(Refer Slide Time: 10:57)

So this way once we have this we went for the cutting and you can see on the hobbing machine this is the you know prototype of the T roller a disc which we have taken to represent the T roller this is a fly cutting table 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 it is having a particular profile and that is being provided by the fly cutter hob like a hobber typically means a single tooth cutter which is generally done for starting experimenting etc okay.

And for unconventional profiles etc so once this was done just a moment towards the end this is the profile which was getting generated the tea crushing roller profile so we showed that it, it can well be done by generation process but we did not pursue it much because ultimately we understood that CMC would be the best option to cut these if we included the full variety of such cutters okay.

(Refer Slide Time: 12:26)

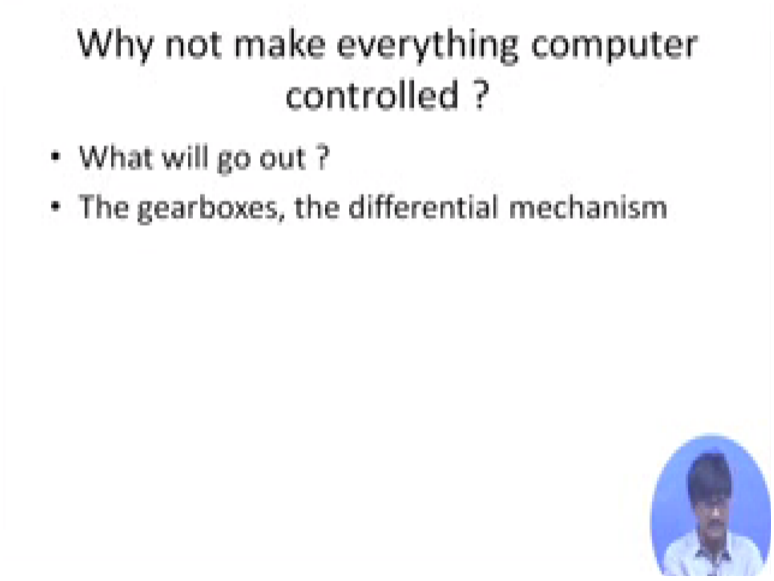


So now we now that we are convinced let us come back to the previous discussion so what are the things that we need to do when we are cutting a helical gear on the Hob by machine mainly three things one is setting the lead change gearbox which we have already seen from the calculations setting of the inclination of the hob if you remember, remember let me remind you when we were working on the milling machine cutting a helical gear the table had to be you know 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 okay 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 that in the direction of motion so that it follows through the cut you know in the same direction so the inclination of the hob also has to be given in the same for the same reason.

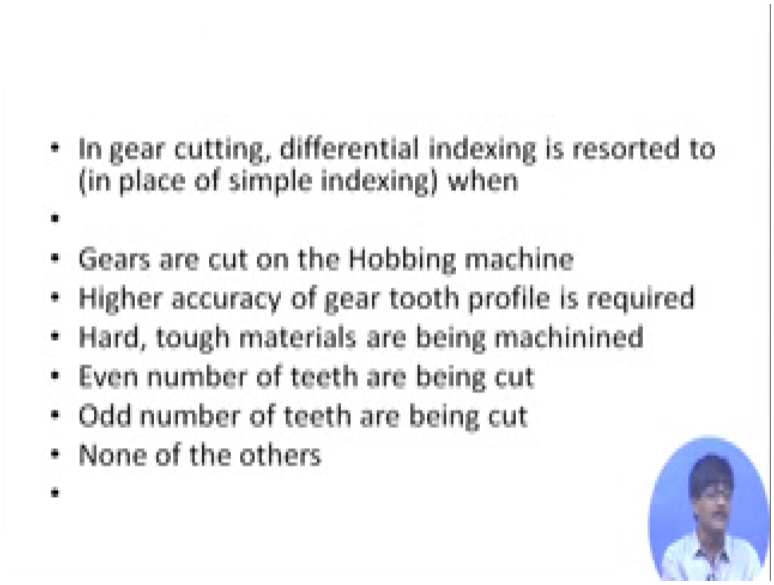
So that even if it is cover gutting the helical groove perfectly it as a physical body has to be oriented in that direction so we will find that the hob is given different inclinations for cutting different jobs for example right and threads left-hand threads spur gears in each case the Hobby is given different inclinations so that has to be taken care of and selection of blank for helical gear with appropriate diameter when we are cutting a helical gear of a particular number of teeth and a definite lead in that key and a normal module.

(Refer Slide Time: 14:26)



We have to calculate the outer diameter and accordingly select the particular blank size which will be having the correct outside diameter all these things we will definitely discuss okay this we have already discussed that we do not make everything computer-controlled though it has its advantages because here though the 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 you know is it is already achievable by the conventional system.

(Refer Slide Time: 14:54)



But CNC machines are coming in, in a big way 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 differentially next thing is resorted to in place of simple indexing when gears are cut on the hopping machine higher accuracy of gear tooth profile is required hard tough materials are machined.

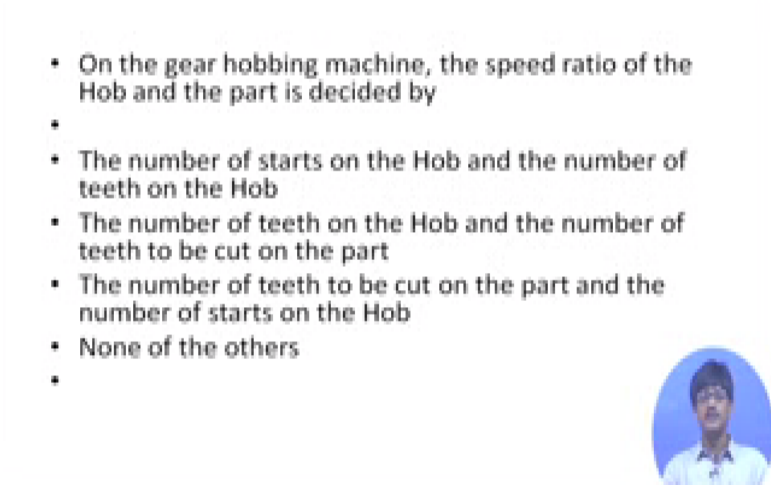
Even number of teeth are being cut or number of teeth are being cut rather than other to be this sort to differential indexing in leaves of simple indexing when gears are cut on the hopping machine no gears are cut on the hobbing machine by continuous indexing okay the differential next thing that we are referring 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 areas over higher accuracy of gear tooth profile no not exactly we require differential next thing when simplistic indexing cannot provide us with the particular amount of rotation which is required in between the cutting of gear okay.

So hardened tough materials in machine no even number of teeth are having no odd number of teeth being cut here I think the way we should we should design these particular options a little more in a liquid alert manner because you know odd number of teeth are being cut this might be allowing some of the options to be you know taken so best is we will say here difference is the answer is none of the others answer is none of the other differential indexing is resorted.

To when the amount of rotation required okay so moving from one tooth 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, I will 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 and on number of teeth we cut so it is true.

(Refer Slide Time: 18:02)



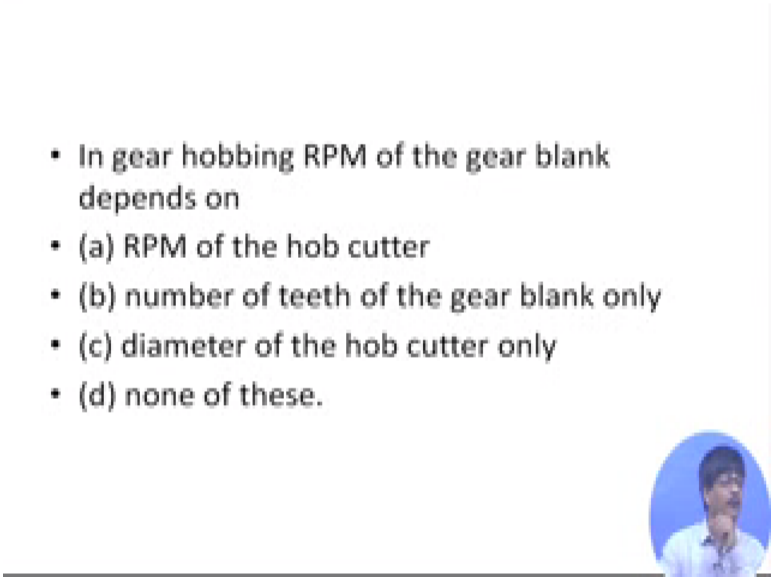
So these two options should be removed in order to make the question well posed so I am sorry I am taking away those two options and then the answer is none of the others so even number and odd number these two options and removing from consideration so on the gear hobbing machine the speed ratio of the hob and the part is decided by okay this is interesting on the gear hobbing machine how do we decide the speed ratio of the top and the part.

We know that the speed ratio of the hob and the part is equal to K/ Z where K is the number of starts and the number of teeth and number of starts on the hop and there 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 given provided in order to give cutting action to the form which is replaced by the hob okay.

The 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

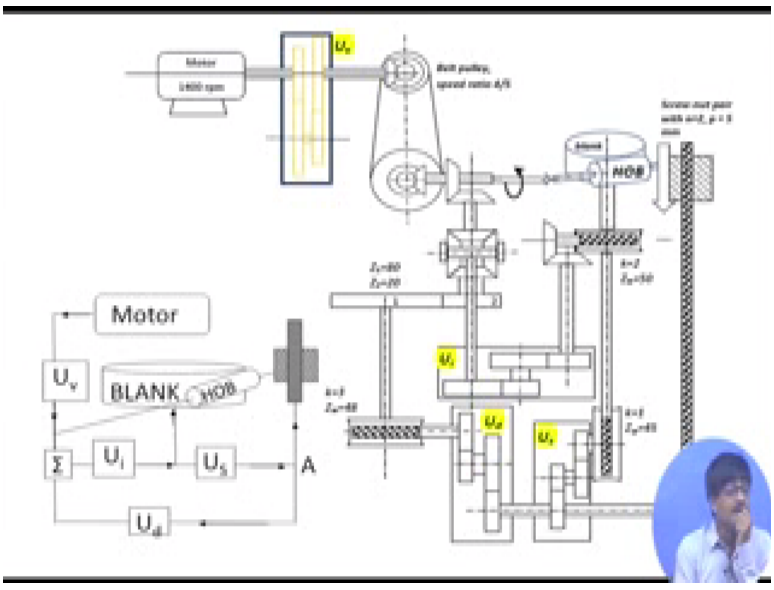
has nothing to do with this so first optional second option both are incorrect the number of teeth to be cut on the part and a number of stars on the hob this is correct K/Z number of stars is K and that is the number of K to be cut on the part so three correct among these options okay.

(Refer Slide Time: 19:45)



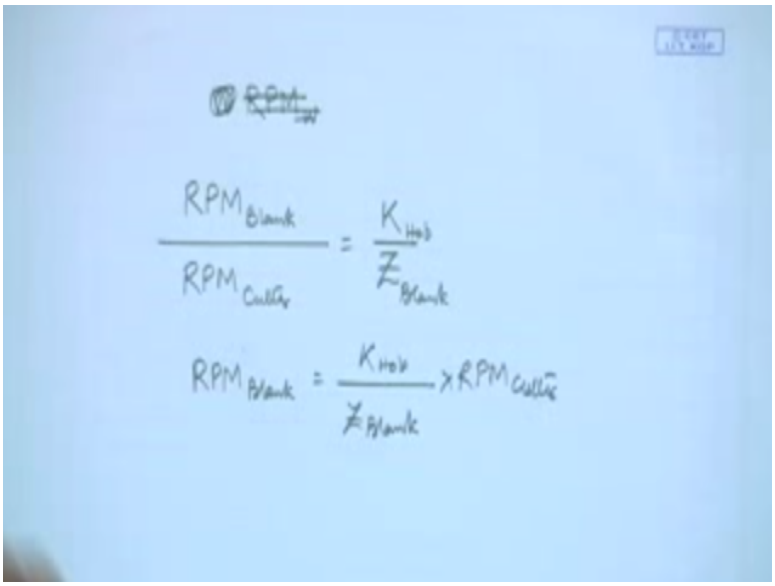
Next in gear being a theme of the gear blank so let us see in gear hobby our theme of the gear blank depends upon our theme of the hob cutter number of teeth of the gear blank only diameter of the hob cutter only none of these so let us see in gear hobbing our theme of the gear blank now what does the RPM of the gear blank depend upon.

(Refer Slide Time: 20:23)



So let us quickly have a look at the main figure once again rotation of the blank rotation of the plank what does it depend upon rotation of the blank essentially depends upon once again K/Z okay so K/Z let us see what are the options present yeah our team 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 say let us take a clear suppose the gear blank is having 40 will the RPM of the gear blank depend only upon 40 no because since it depends upon the ratio K /Z okay if it depends upon the ratio K/Z definitely it will depend upon K and not only K.

(Refer Slide Time: 21:37)

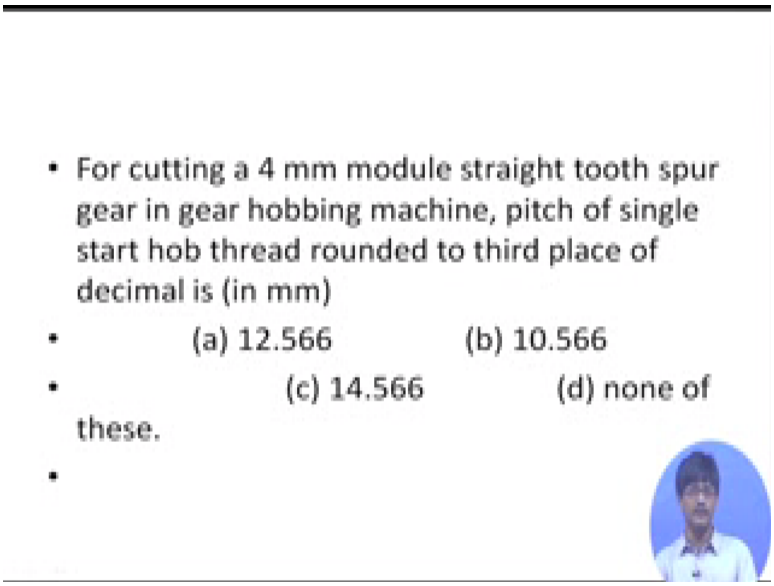


Since let us write this down rpm of all work piece so we write work piece rpm or other we will write RPM work piece or we have used the term blank so let me cut this rpm of blank divided by rpm of cutter equal to K by Z of blank K of table from here we can say rpm of blank equal to K of by Z of blank into rpm of cutters once we have established this it becomes extremely simple

so if we go to the screen once again rpm of the cutter yes RPM of the cutter is appearing here RPM of color it depends upon RPM of cutter second is number of teeth on the of the gear blank only is number of teeth is here yes number of teeth here.

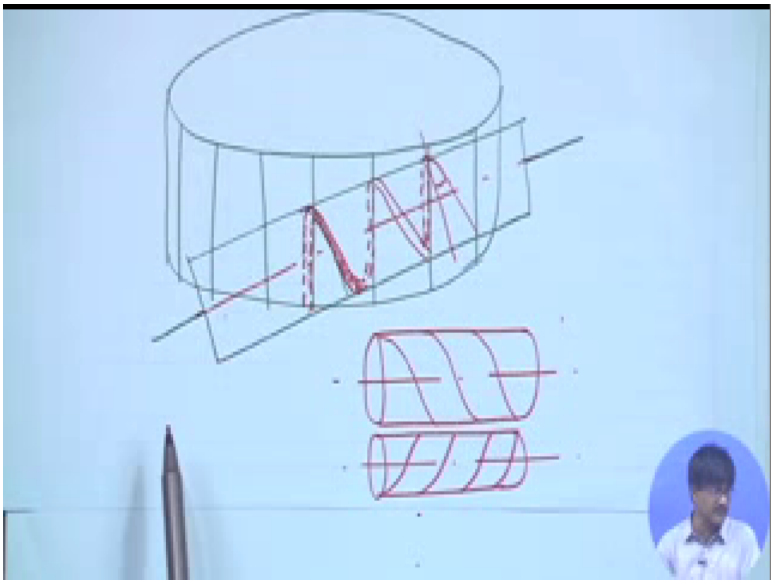
But there is the word only and we were supposed to be very alert on this therefore second option is not correct second option is not correct if we come to this option once again sorry second option is not correct now let us see the third option diameter of the hob cutter only now there is diameter of 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 in gear hobbing rpm of gear blank depends.

(Refer Slide Time: 24:11)



We come to the conclusion that in gear having RPM of the gear blank depends upon RPM of the hop cutter first option is correct next sorry now for cutting a foam module four millimeter modules straight tooth spur gear in gear humming machine pitch of single start of thread rounded to third place of decimal is there are four options given now what is exactly meant by this question I am trying to cut a straight tooth spur gear now for cutting the straight tooth spur gear how much is the module of that it is having four millimeters module I am using a gear hobbing machine so the pitch of the single start hop thread rounded to third piece of decimal has to be found out.

(Refer Slide Time: 25:08)



Now for that let us draw a figure first of all this figure will explain a number of things which we have this I ever 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 warm and warm gear cutters and environment warm gear mechanism spares the warm is not inclined why because the warm 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 the helix angle okay suppose the helix angle of the of the teeth they are such let, let, let me see a different color if this be the helix angle on the other side it matches that the direction of this part like this so this, this is the thread of the warm and this is the side that I can see I can see this side this thread the one tooth side which I cannot see I mean the thread which I cannot see of the warm it is on the other side and it is in connection with the thread with the teeth of the spur gear.

And therefore it must be having this particular inclination which is matching with the spur gear therefore once again if they have a look this particular form must be having an inclination which makes its teeth match with the teeth sorry which makes it thread match with the teeth of the spur gear in the in the place of contact between the two okay and therefore it simply means that I must have rotated it by if this be the helical 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 okay so now first of all if I am cutting a helical thread if I am cutting a helical thread so in that case we first have to find what is the hand of the helix okay so when we are talking about the hand of the helix the Hob can have a hand of the helix this form sorry gear can have a particular hand of helix.

So first of all then we are looking at a threaded element this is one hand and this is another hand of helix so sorry this is slightly away from them so this one is right hand and this one is left hand so there must be a V in which it can be properly defined so right hand when we are taking a right hand hob and we are cutting a left hand so there can be different combinations first of all six combinations or 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 a left hand helical gear and vice versa so, so many cases are there and in each case we find that ultimately at the plane at the place of contact the inclination of the thread of the warmth 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 hub in each of these combinations thank you very much.