rotating screw thread to a gear this is a big achievement. Previously we were transferring motion from worm from one gear to another gear you were transmitting motion from screw threads to nut etcetera, but we were not able to in any way move from a screw thread to a gear directly this is being done here.

And there is a very important function which is being served by this worm and worm gear mechanism, incidentally the speed ratio that means N worm gear by N worm this is the speed ratio that means the warm gear is being rotated and the worm is the driving member. This one can be shown to be equal to K/ZW where K is the number of starts on worm and ZW is equal to number of teeth on worm gear.

So from this we understand that a very useful purpose will be served by this mechanism what is that jelly the number of starts is equal to 1, 2, 3 like that and the number of teeth on the worm here can be typically say 80, 40 like that. So let us take an example in which K = 1 and ZW = 40 what is the speed ratio we get the speed ratio will be a thumping for 1/40 so just imagine a rotation on a shaft can be reduced to 40 times its original value why is this so important and why is this so useful let us have a look here.

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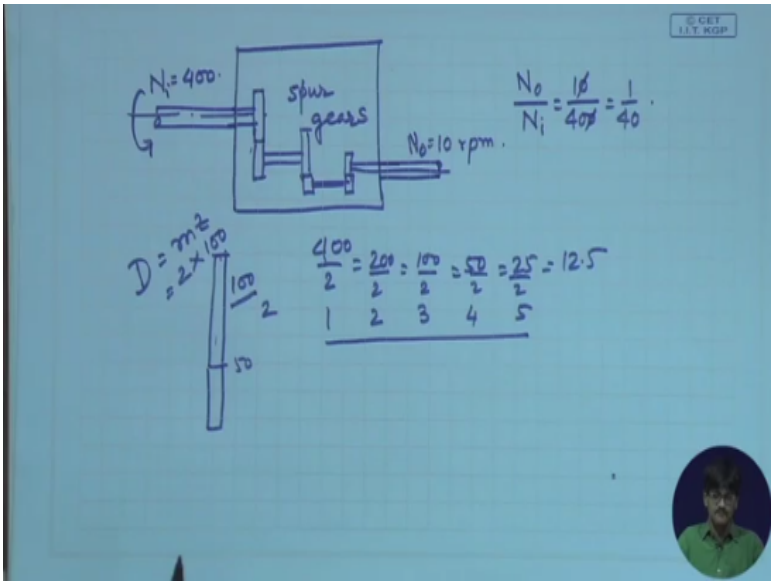

If I am having say an input shaft with rotational speed equal to 400 and if I tell you that make a gearbox into which it is moving in put whatever ordinary gears that we have discussed up till now spur gears I will come to this term spur gears, but whatever spur gears that you can put in

and get me a speed of how much 10 rpm. So you immediately find out what is the speed ratio required N output, N input.

N output by N input is equal to 10/400 = 1/40 so you decide okay fine I can put gears of this type maybe sorry, drawing is not very good what is input gears of this type and maybe reach 1/40 let us see how difficult it is whenever we were talking of gears which are having say 100 teeth, 50 teeth okay what sort of speed ratio is possible here 2. So if you are going on putting gear of this type as an example so 40/2 in 1 stage you can get 20 rpm, in the second stage you can get sorry, in 1 stage you can get 200 rpm, second stage you can get 100 rpm, another stage 50 rpm, another stage 25 rpm, another stage how much 12.5 rpm.

And this is more like the 10rpm that we were requiring. So you would have had to use stage 1, stage 2, stage 3, stage 4, stage 5, just imagine 5 steps in here, here I have only drawn 3 steps and that 2 you know when you are accommodating gears of 100 dynamic, 100 numbers of teeth and if the module is say 2, therefore the diameter you which you would have had to accommodate would have been 100 D if you remember D = mZ, m=2 and number of teeth is 100 so it would have been 200 millimeters just imagine.

This way you would have covered 200 millimeters, this would have given rise to 100 millimeters, 300 millimeters in every stage 5 steps such stages. So in the most general case it would have given you a huge space a gearbox requiring a huge space. Now we would not be interested in that sort of a gearbox if just to get a reduction of 400 to 10 you would be requiring say 2 meters by 2meters of space no one will interested.

Here in comes the worm and worm gear application of the worm and worm gear, you can notice here by the worm and worm gear we had this discussed just now, in one step itself you can reduce the speed from 400 to 10 by employing k =1 and z=40 teeth as simple as that okay, this is the advantage of the worm and worm gear, drastic speed reduction in a single stage drastic speed reduction there are problems associated with worm gears and sometimes those problems are made use of for example you know for specific helix angles and coefficients of friction this is self locking that means by rotating the worm you can rotate the warm gear.

But by rotating the worm gear you cannot rotate the worm okay, some particular properties like that they are associated with worm and worm gears, but this is a big thing you can get drastic speed reduction in one stage okay.

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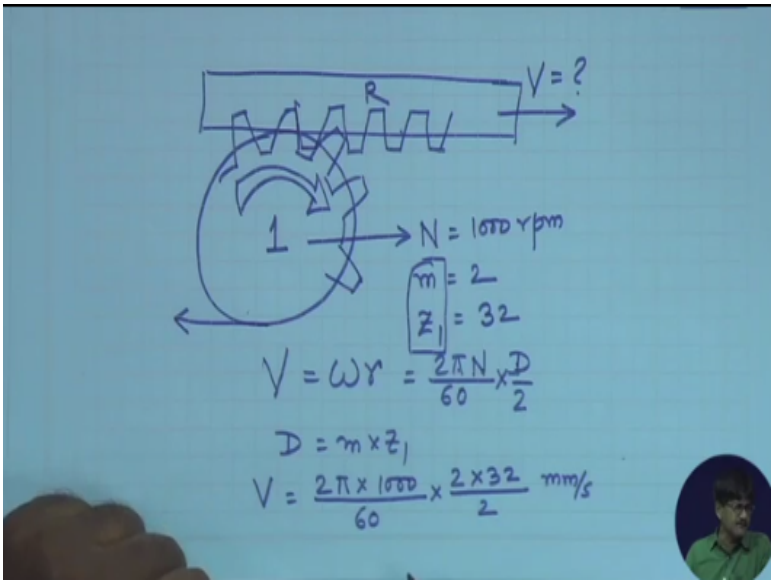

Now let us take the case of rack and pinion let us take a simple problem also say I have this as a gear depiction of a gear and this as the rack. Suppose I give this information this one is rotating and is called 1 and this is called R, for R I am interested to find out the velocity it will develop, and here I am having N = 1000 rpm module equal to 2, number of teeth equal to 32 what will be the speed developed by the rack.

So in this case what we do, in this case we can say that I can easily find out the peripheral speed of this gear at the pitch circumference. Once I find out the peripheral speed of the gear I can equate it to the rack speed and that will be my answer how do I find out the peripheral speed if

you move from first principles you can say velocity has to be found out, if velocity has we found out it can be equated to ωr this can be equated to 2ЛN/60 okay ω x r let us say D/2 okay.

Now this n is in rotations per minute is it given yes it is given, if the diameter provided no I do not know the diameter, so how do you proceed here you will find once again if M and Z they are provided you can use D = M x Z1 and you can put it here. So 2xЛx1000/60 gives you number of what you call it here we are putting ω therefore in RPS 2xЛx1000/60xmxzx2x32 let us write it down.

Therefore, V=2Лx1000/60x 2x32/2 and since this is rotations per second and this is in millimeters we have millimeters per second this is the answer, some calculations are required I am sure you can do this and solve the problem. So now we have covered gear trains, screw nut mechanisms, worm and worm gear mechanisms, rack and pinion and therefore we can carry out all the calculations which are required to understand how machining or cutting of gears takes place.

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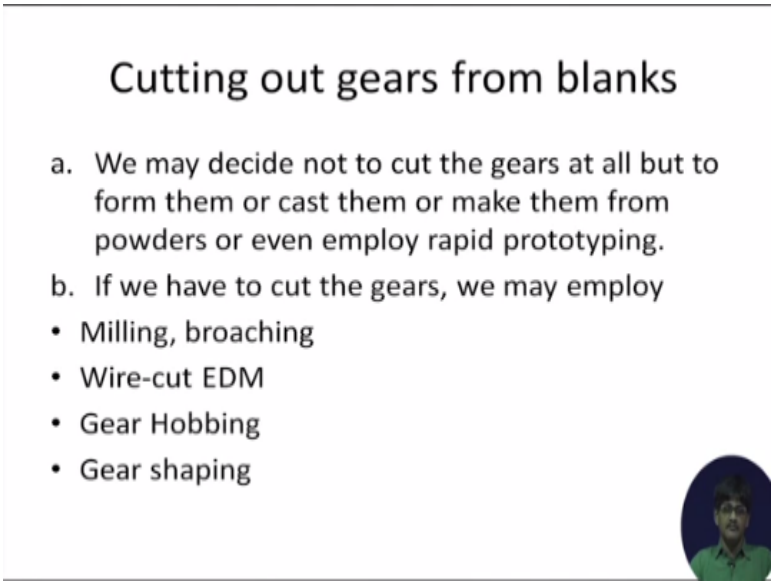

Now coming back to our original discussion let us now take up the methods by which gears are cut out, but before that we should notice that gears are not produced only by cutting or machining, machining basically means cutting with the removal of unwanted material in the form of chips from a larger sized blank. We might not always cut gears out of blanks we might get gears made by completely different means.

We can go for forming them like die casting, stamping etc, etc, or even a blanking. So we might also cast them okay or we might be getting them by means of powder metallurgy or even employ rapid prototyping all these methods are involving either cheapness, manufacturing or they are primary methods of manufacturing or powder, metallurgy, practice or rapid prototyping etc, etc. So they are completely different from cutting of gears, but a whole family of methods of cutting out of gears have evolved over time and they have their own areas of specialization like there will be some cases in which they are very much essential to be used okay.

And we will be studying about those things so what are the typical methods of cutting or gears we might have milling, we might have broaching, we can also have wire cut electrical discharge machining, we can have gear hobbing, we can have gear shaping, and we can have yet different other methods. But these are roughly the most generalized processes and they have their respective areas of special applications.

For example milling what do you exactly mean by milling I can cut out a gear by say for example a rotary 2/3 cutting what you call a rotary cutting tool. So what do we exactly mean by this rotary cutter okay, this is basically a foam cutter.

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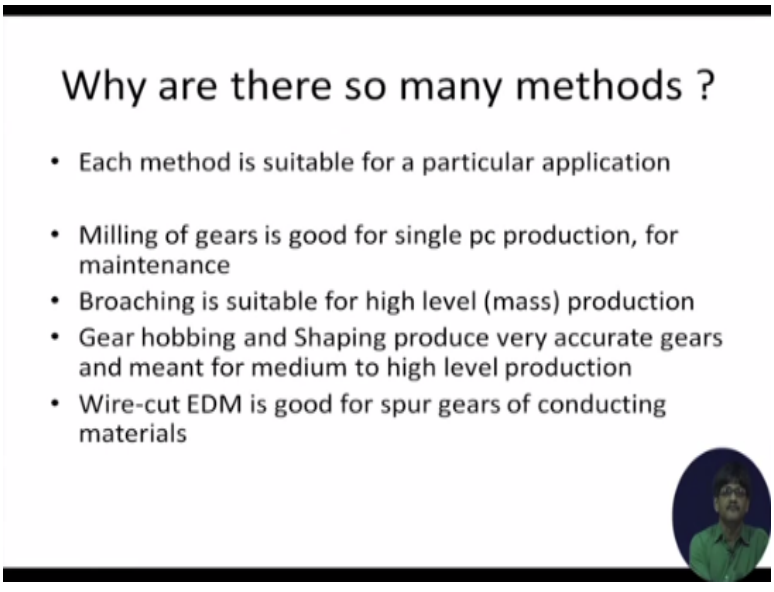

And let us have a look at that what is its area of application, so milling of gears is good for say single-piece production for maintenance etc, suppose you're working in a factory in a night shift

and there is one gear on a machine which fails you gets damaged, so that it has to be replaced immediately. So what do you do, do we go to a shop no because in the night time most of the shops are closed, you go for online ordering it.

So that it will be mailed to you and you will be receiving it through courier no because that takes certain amount of time you cannot manage to get it immediately, but you can have your own machine shop and you can have a milling machine which can be set up very fast and rotary form disk type cutters which I have referred to or N mill cutters which once again they are foam cutters they can be employed with a method of indexing.

So that you can easily get such a gear or there is other examples suppose you are having a job shop in which you are depending upon orders which are coming from time to time and somebody places an order for two such gears, five such years etcetera. So for that you cannot have a specialized machine you have to have a machine which can be quickly set up for that kind of production and maybe it will even be manually operated and though it seems to be not very molecule, not very significant this sort of production it might have a considerable volume okay.

That means there might be huge number of customers who would be approaching you with orders of say 2 to 3, 5 to 7 pieces of such gears for which you cannot spend money to have a specialized machine dedicated for that purpose. So instead you have generally a memory or political machine in which setup can be done very fast for doing that job and then you can change the setup for some other job that you might be having inline.

So milling is good for that, so milling is used in such cases broaching is suitable for high level production okay, and it is a single pass method so that it is very much desirable battery we also have gear hobbing and gear shaping which can result in quite accurate gears, because it they do not have the errors and in accuracies resulting inaccuracies of milling etc, and therefore they can use be used for medium to high level production wire cutting EDM, wire cutting EDM if you have conductive materials and if you are having spur gears to be made then wire cutting is quite good.

But if you have helical gears it is, it cannot be handled by wire cutter at this juncture I think I should introduce the difference between spur gears and helical gears.

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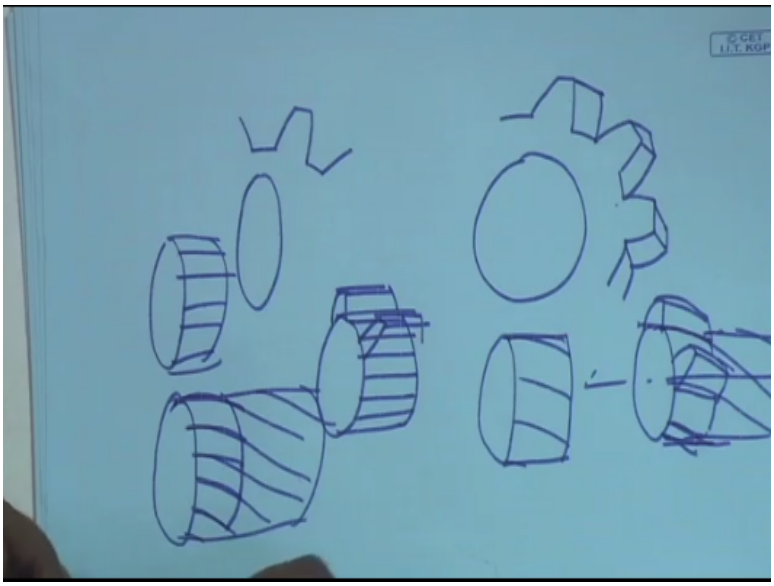

If you have a quick look here I can have a gear of this type the teeth are of this type as we have been drawing sorry, teeth are of this type that means if you look along the axis of the gear the teeth are straight, so that when you draw them you can draw them this way etcetera. But you can also have gears in which the heat instead of being straight okay here we have drawn gears which are having straight teeth that means these teeth are this way instead of that, they might have this way that means these tip will be looking this way which actually means that these are basically parts of helixes about this particular central axis.

So it will be ultimately going this way okay so if I am talking about a helical gear it will look like this, all these helixes are there and I cut it from here I get my particular helical gear. So while spur gear the teeth will be like this parallel to the axis the helical gears will have the teeth in the form of small portions of helices about that particular cylindrical portion okay. So this is the difference between spur and helical gear tomorrow I have a plan to show you some actual helical and spur gears by bringing them here and putting them on display, so that you will be convinced okay they are definitely different. So with this one we come to an end to the second lecture we will meet again for the third lecture thank you, very much.