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Course
On

Spur and Helical Gear Cutting

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Lecture 12: Gear Shaping- II

Welcome to the 12th lecture of the series spar.

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And helical gear cutting last time we were discussing a figure in which you know.

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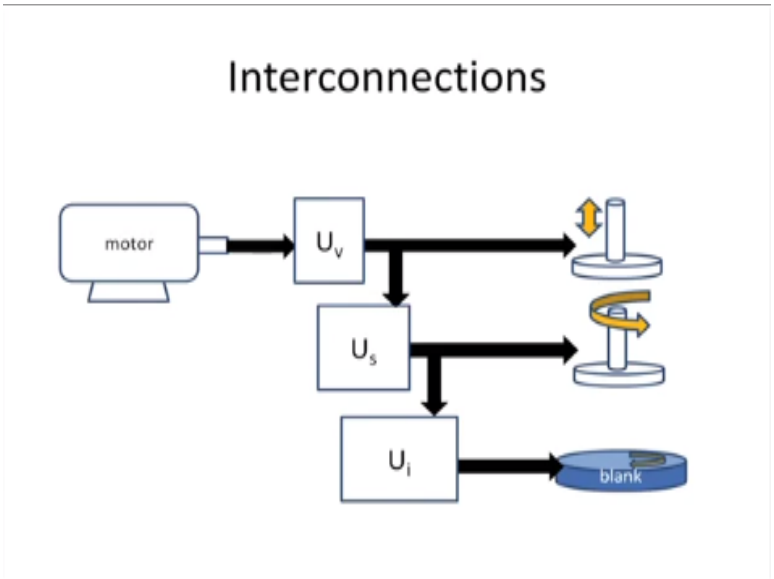

The setting of the gearboxes had been shown and we had discussed up till this point that the location of the gearbox UV apparently affects everything downstream, so that first of all the feed of the you know feed of the material rather feed of the cutter against the work piece might be affected but our discussion showed that the way in which feed has been defined as millimeters per stroke that remains the same even if UV setting is changed so we noticed that UV was a change in UV made a change in case of the strokes per minute.

But it did not affect the feed value now comes the question, so we also need to check does it affect the number of teeth being cut because number of teeth how is the number of teeth decided okay how is the number of teeth decided that is very important let us have a look at that so for that kindly have a look at this at the paper.

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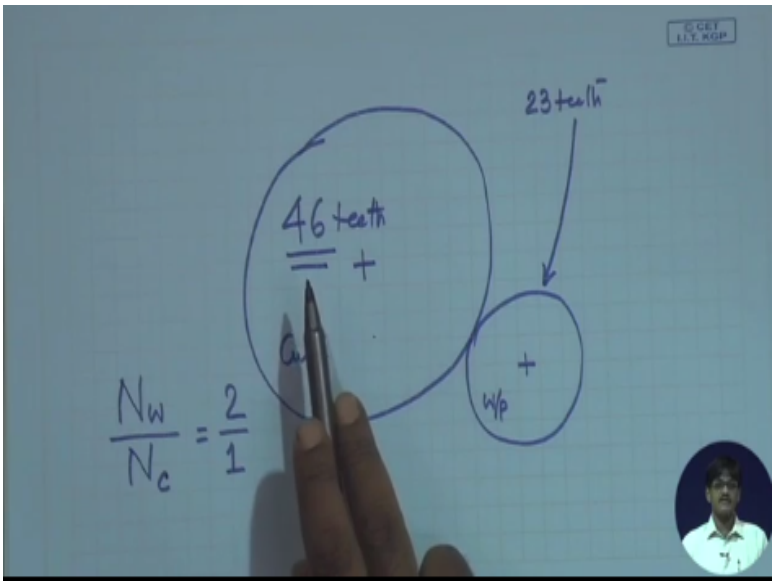

We have this as the cutter the cutter is also a gear as we noticed in the simulation and say this is the work piece, so cutter work piece now how are we going to decide how many teeth are going to be cut suppose I decide that I want to cut say 23 teeth if I want to cut 23 teeth on the work piece suppose the cutter is having 46 teeth then first of all by calculation I have to find out the correct outer diameter the correct outer diameter has to be decide I mean determined for the work piece and accordingly up blank with proper outside diameter has to be machined out for 23 teeth and if it meshes with 46 gear.

Of the same module in that case they would have a definite speed ratio what will be the speed ratio the one with larger number of teeth will definitely have slower rpm and then therefore we can say N work piece by N cutter okay this will be double the rotation of the rpm of this one and therefore we can say this is equal to 2 is to 1, so that means on the gear shaping machine where teeth are not existing on this one if we can produce a speed ratio of 2 is to 1 between the cutter and the work piece.

In that case we will be achieving ok we will be achieving our speed ratio of 2 is to 1sorry I made a mistake so that means that if we can maintain a particular speed ratio between the cutter and the work piece accordingly a definite number of teeth will be cut so if we provide this an RPM of say hundred and we separately provide this an RPM of 200 we will find that it will cut 23 teeth if the cutter has 40 60 this is basically the statement okay so with this idea now let us have a look

how we are going to proceed for the cutting, so to start with let us come back to the figure so in the figure UV been doubled as we discussed previously.

U_V has been doubled so to sum up this particular part if you see this to sum up number of teeth on the work piece it is completely determined, by the ratio of the rotations that you are providing to the cutter and the work piece okay, If you set a definite ratio accordingly a particular number of teeth will be machined on the work piece provided we provide the work piece with a blank with the correct outside diameter if you provide a wrong diameter something will you know go wrong and brushing will take place.

I mean rubbing will take place between the cutting cutter on the work piece which will ultimately spoil the teeth okay, so to come back our discussion U_I should determine U_I the gearbox for determining number of people should determine the ratio of rotations of the cutter and work piece this ratio of rotations should not be affected either by U_V or by U_S okay, so now let us let us cross check that how is the ratio of the cutter rotation this is the cutter rotation and the work piece rotation affected.

So in the loop that we have between cutter and the work piece this is the flow of power this is the flow of power here we were moving backwards here we move forwards we reach U_I and then we reach the blank, so we understand that the ratio of rotations of the cutter and or peace or the blank can only be affected, by elements which are present in this loop who is present in the slope symbolically we are shown only U_I only U_I is present between the cutters and the blank and that way this configuration is correct and if U_V is changed if U_V is changed it will equally affect the rotation of the cutters.

As well as rotation of the work piece because it is outside the loop what does this mean this means that suppose U_V is doubled so that its output rpm gets doubled if the output our team is getting doubled okay it passes through us whatever change that brings in the other the change in rotation that means the factor getting multiplied due to the change in rotation that factors will be multiplying the rotation our theme of the of the cutter and the same factor will be multiplying the RPM of the plant and their rpm ratio will remain the same, so if some machine element are sorry some you know gear box or something like that U_V or U_S or whatever else is outside this loop connecting up cutter and the work piece, they will not be able to affect the rotational ratio and therefore the number of T being cut on the blank.

This is what we understand therefore this configuration is fool proof of UV affects only cutting speed us affects only the feed of the cutter and UI affects only the body collect number of teeth being cut on the blank, suppose I want to find out how is us affecting the feed can I make this feed higher or lower by changing U_S, okay if we are changing us okay if we are changing us the cutter starts rotating say faster so suppose us is the setting of the us is changed so that this rpm is doubled so the cutter starts rotating twice as fast okay.

Now in order that the cutter and have the same rpm ratio this factor which has changed at the output of U_S that is also brought here and the blank starts rotating twice as fast, so they still retain the rpm ratio in between, but in addition they are moving fast against each other so that the circumferential movement they suffer per stroke that has changed why because the strokes per minute have remained constant while the millimeters of circumferential movement per minute that has changed.

If that increases therefore millimeters of circumferential movement per stroke equal to the feed that will become higher okay, so with this let us move on to other configurations and check why we chose that particular configuration and not one of these and sequentially you will agree with me that all of these have some problem because of which the configuration that we started with can be considered to be unique, so if we consider this configuration say some student comes suppose I am assigning a particular task to a student who has just become conversant with gear shaping connect up all the gear boxes with the motor.

And all the machine elements that they are supposed to serve so the gearbox U_V is supposed to serve the up and down movement so it is connected us is supposed to serve the circumferential movement of the cutter and of course the focus also and therefore you connect it U_I is supposed to control the ratio of rotations you connected with the blank rotation and instead of the previous connection suppose a straight, cut I tap power from the motor and give the connection to all the gearboxes now is this alright. So let us check what possible problems or it might be giving rise to I change the gearbox setting of U_V and we double so number of strokes get doubled I find that the millimeters per minute that is not changed.

So millimeters per minute divided by strokes per minute becomes half so if you double the speed in this configuration unfortunately you will find that you have reduced the feed by a factor of

half okay, so this sort of direct connection of the gearboxes in the motor at least for these two they are not admissible, second one if we connect with the motor directly the U_S and the U_I gearboxes suppose in this case I change the feed by changing U_S suppose us is double the rotation rpm the rotations per minute of this cutter becomes double at the same time since the UI is drawing power directly from the motor.

It is rotating at the previous rpm and therefore you will find that the rotational ratio of the gear blank and the cutter that has become different, so we started out to change the feed and we found that ultimately the number of T being cut that has got affected so this particular connection also of direct connection between U_I and the motor this is also not acceptable, so once you have got the hang of this logic you can unravel any particular configuration that I will be providing you what about this U_V is here U_S is here U_I is here.

Let us take them one by one since in fact we can move very fast through it, now we can say here if U_V is connected to the motor and us is also connected to the motor directly something is going to go wrong what exactly suppose you change U_V now number of strokes get say doubled but U_S is not affected because it is drawing power from the motor directly so millimeters per minute divided by strokes per minute that is again going to become half is it going to affect the what I call it the number of teeth being cut.

So if I change speed if I change speed the if I change speed the number of strokes per minute they are becoming changed, but the feed unfortunately it is gain getting affected but fortunately the number of T being cut that is not going to get affected, because the position of us is such sorry the position is U_V is such that it is not affecting the RPM ratio as you can see bifurcation is has taken place from the very beginning okay, so here the problem is that feed gets affected, if I change the feed gear box here if the RPM is the number of T going to get affected no because in the loop between RP rotation of cutter and the rotation of work piece U_S is outside that loop it is not going to affected.

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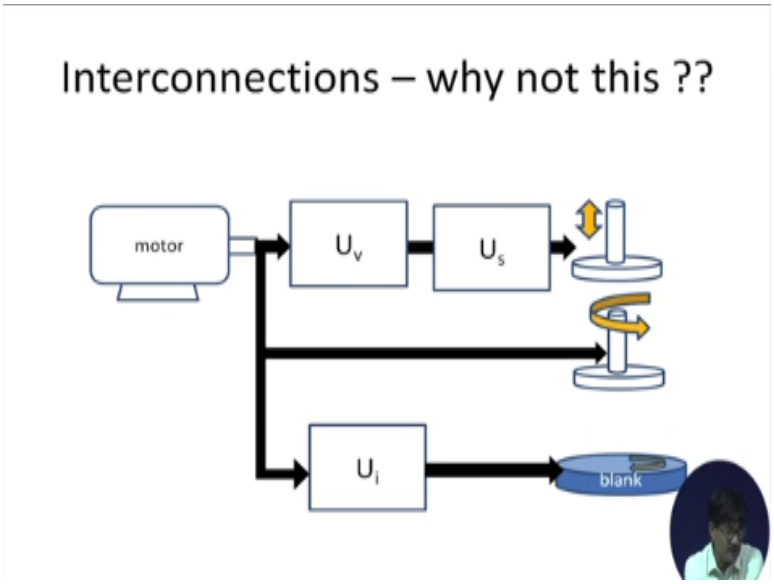

This configuration this look looks quite funny U_V and U_S they are just side by side suppose I change the speed if I change the speed, speed will change there is absolutely no problem what happens to U_S, U_S unfortunately is not in the line of cutter rotation at all, so it would not be able to affect the cutter rpm, so unfortunately us is not going to serve its purpose if U_S is changed we will find that it is simply doing the task of changing the number of strokes per minute. You might say cannot change the speed feed that way yes we can right because.

We are now we have now put U_S in a particular location because, of which it can affect the denominator of the expression of feed, suppose I make U_S double in that case speed will become half you will new U_S since they are in series they are going to serve the same purpose, now that is simply serving the purpose of changing the number of strokes per minute and as the bifurcation of power has taken place before them, they will also affect feed so that means feed and speed will both be affected by the change in U_V and U_S now.

Let us have a look at number of teeth are they going to affect the number of teeth no because they are not in that particular loop.

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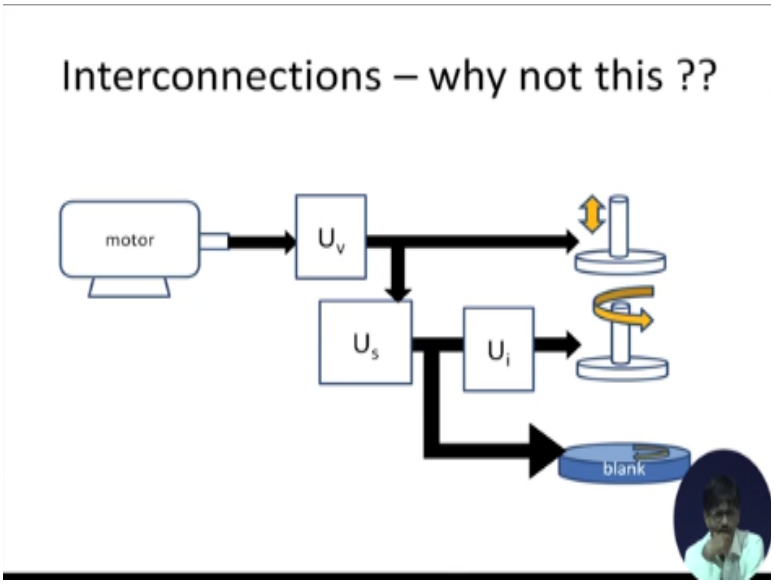

What about this one this one looks good U_V is coming first as in supposed to be latest because we know the solution, but obviously after this something is going wrong U_V is placed just ahead of the cutter rotation, now you might say what is wrong with that you I is supposed to be put in between the cutter rotation and the work piece rotation and it has been placed that way only, so if I change U_I it will affect the other rpm ratio and therefore it will affect the number of teeth being cut the problem if you change U_I with that in mind it will also affect the feed that means millimeters per stroke.

Which because it is simply going to change the rpm of the cutter if the rpm of the cutter is changed, okay per stroke it is going to lead to a different feed value but was not it leading to a different feed value when it was put in the lower line, we will discuss we will definitely discuss that as well, so in this case we understand U_V has been placed correctly U_S has been placed correctly but U_I has been placed in such a way that it will affect the feed if we change it for a different for cutting a different number of teeth.

This one this one have not we discussed it before, no we have interchanged the locations of U_S and U_I what does this mean this means that U_S is, now in between sorry in between the motor and the cutter, okay just a moment I think we can discuss an even more interesting problem slightly different from this one which comes to my mind. Let me draw it on the piece of paper.

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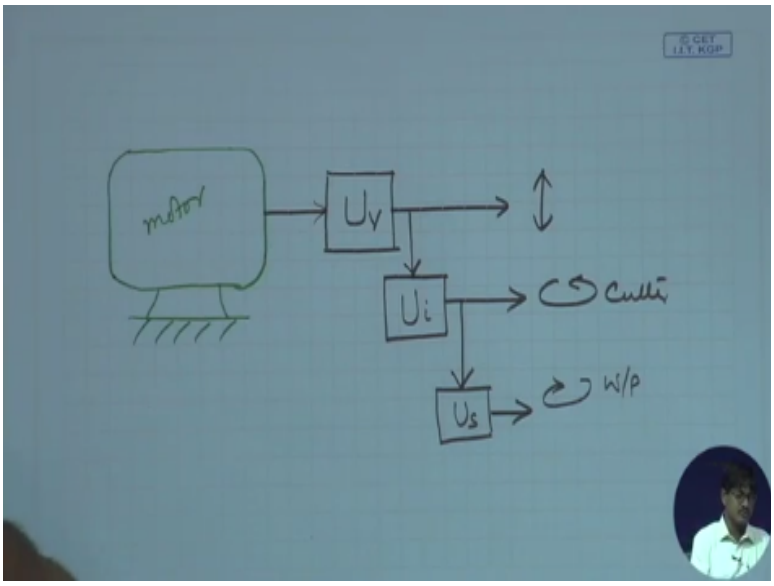

Please have a look at the paper this is our motor this is output from the motor, we have gearbox up-down rotation of cutters and rotation of work piece, and here we put U_I and here we put U_S and here we are having U_V that means if I change the positions of U_S and $_{UI}$ what is going to happen, so first of all U_V serving its purpose and after that you I is outside the loop of the cutter on the work piece, so obviously U_I is not going to serve its purpose by because even if you change UI we will find that the ratio of the rotations of the cutter and the work piece it is not.

And what about US being put here, yes if you change it is simply going to affect the number of T being cut, so if you by chance put it this way the problem will be that this is going to affect feed and this is going to affect the number of T okay, just the opposite of what they are supposed to do. So in this one we were discussing that only, so I made it the correct configuration and then we discuss what is going to be the problem.

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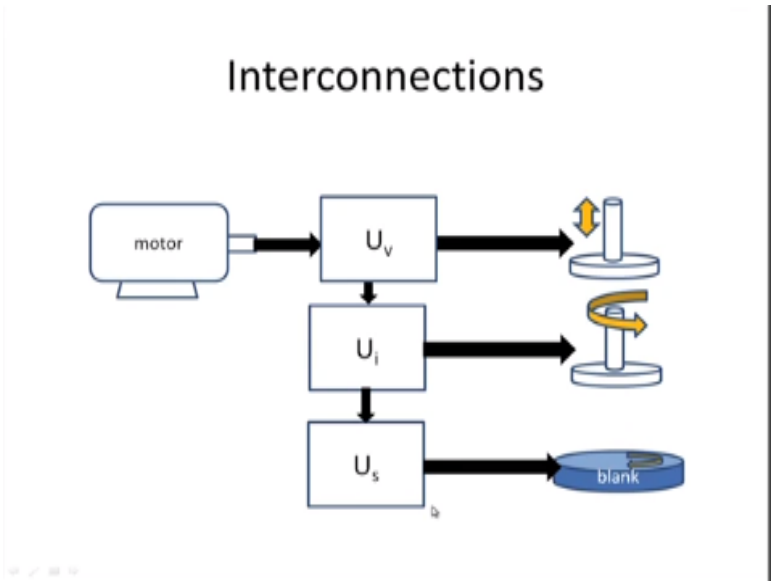

Now what is the configuration here the interconnections that we have been discussing all this time I think this is this is the correct one.

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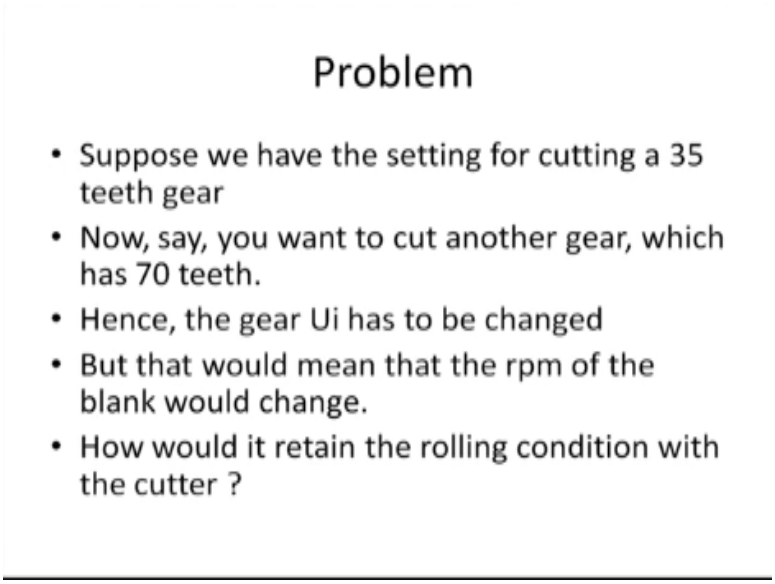

Now let us yeah let us take up this particular problem what does this problem say, suppose we have the setting for cutting a 35 teeth gear we are setting the we are having the setting for cutting a 35 gear 35 teeth gear, now say you want to cut another gear which have 70 T so 35 T spur gear has to be cut and you have cut it and the setting of the machine is for the 35 teeth, now you say that yes my second or next assignment is to cut a 70teeth gear of the same module, you want to cut a 70 teeth gear now.

Hence the gear U_I has to be changed so if the gear U_I has to be changed okay how much would it be I mean what are the changes in the others no other change, so this would be that the rpm of the blank has to be changed, when the rpm of the cutter becomes different there is no need if we can change the rpm of the blank by a different value of U_I that should serve the purpose but how would it retain the rolling condition with the cutter, now let us try to understand what it means it means that and keeping the cutter rpm constant.

So that it is peripheral speed is remaining constant at the same time I am changing the work piece rpm if the work piece rpm is changed therefore previously it was having rolling action with the cutter, how come it will retain that rolling action still shall I draw a figure to discuss this one.
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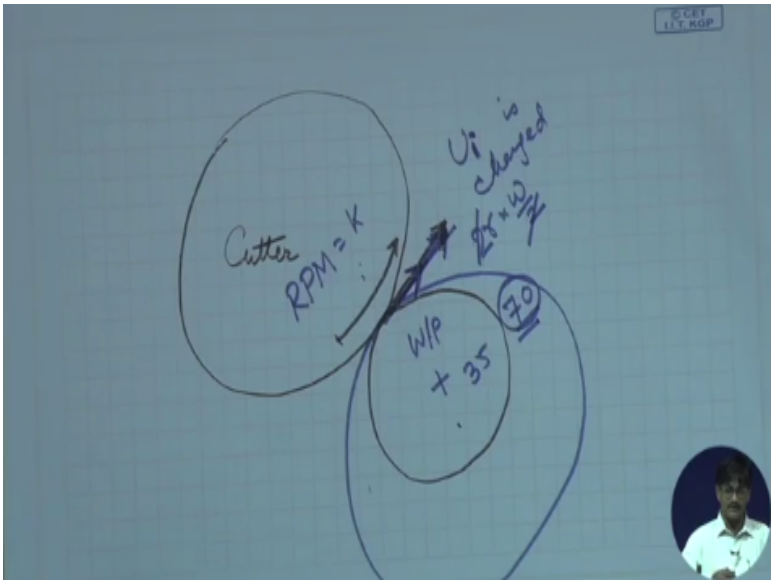

Let us see please have a look at this paper this is the cutter, oh it is cutter and my god looks almost like an ellipse Carter and this is the work piece this is say this represents the rotational speed of the cutter, so this is the speed widget that develops the velocity at its periphery now was

rotating it was rotating it was matching this speed this is the work piece it was matching it was having at this point of contact they have the same speed they are the same speed work piece, now for 35 teeth this was the case.

Now I make it 70 teeth I am making the setting for 70 teeth which shows me from the figure that U_I is to be changed UI is changed if you eye is changed if U_I is changed that will give rise to a different rpm of the work piece and therefore it appears that the cutting speed should be changing its are either this peripheral velocity should be changing, okay it will become this one this much then how can they have the same velocity of the peripheral cutter is not changing its rpm so we write rpm is constant.

But this one is changing its rpm so that this peripheral velocity is becoming say half apparently then they will not be in rolling condition anymore, so how to solve this problem the solution to this problem is this that when you are going for a 70 tooth gear you are surely changing UI and that is surely going to reduce the rpm of the work piece to half of its value but this one this velocity will still remain the same because for a 70 tooth gear the blank is going to be a larger one so since this velocity is equal to r into ω.

Okay ω is becoming by 2 and r is becoming twice r so that r ω still remains constant physically I am putting a larger blank here, which is bringing in a larger radius and therefore this particular velocity still remains the same and matches with the cutter and therefore only this still takes waves U_I is definitely changing and reducing the rotation and larger diameter still ensures that the velocity remains same as that of the cutter okay, so in the small amount of time that we have in this discussion I will just touch the case of the in feed.

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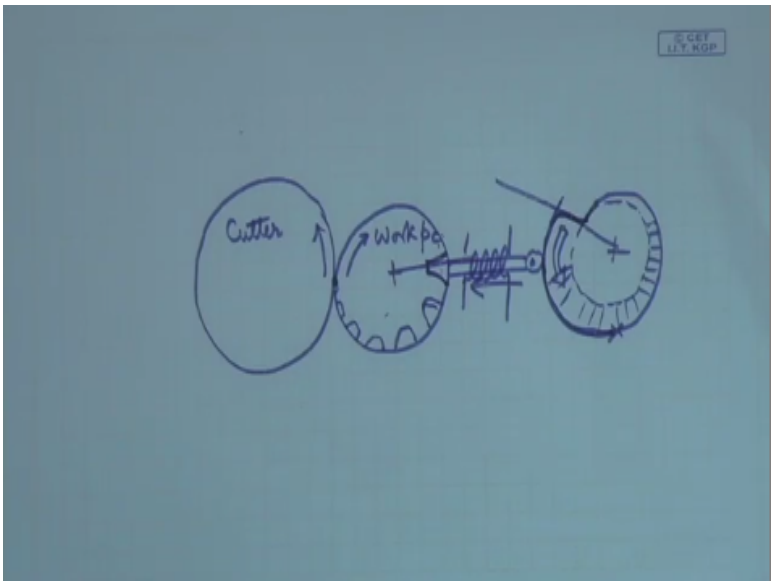

Which we have not discussed up till now how does the in feed take place in feed takes place this way we have the work the cutters, we have the work piece cutter work piece, okay initially they are touching tip to tip there is no cutting taking place and then they start when they are rolling at the same time this is moving in okay, gradually these teeth will be getting higher and higher values of cut that means when this one comes here it undergoes this amount of cut this one comes here it undergoes a little more time amount of cut etc. So this way after a certain amount of rotation we will find that the full depth gets reached.

We reach the full depth so maybe theoretically say we find sorry theoretically say after this amount of rotation though is much higher, and this may be 2 or 3 at this stage you reach the full depth, after that do you give in feed no because if you still goon giving in feed so this one comes here gets a particular cut this one comes here gets a particular cut like that. So when this one will come here it will get the full depth because it has gone on moving it went on moving towards the cutter while the cutter remains stationary.

So when this particular radial position comes it will undergo full cut and when it undergoes the full cut after that radial in feed stops at that time there will be a dwell that means that they will go on rotating still while this one does not undergo any in feed and at that position we have to ensure that all of the of the teeth they undergo this particular full-depth, and therefore say one at least more than one rotation is made so that the cut is now taken up by all the teeth on the

peripheral once that has been done it is ensured that all the cuts all the teeth have been cut properly.

And after that it can rapidly retract at the end of the cut this can be provided by a cam how does the cam look like it might be looking like this, so in this camp first of all this is the base circle so from this circle as this particular profile is deviating it means that if there is a push rod if there is a push shot, so as this is rotating this way as this is rotating this way it will push this rod towards the cutter and if the work piece is somehow attached to it will start moving this way in addition to its rotation.

So if we start from here that is when this position is here this one starts rotating and gradually the amount of push okay that is increasing and after sometimes we will find that further increase is not required because it is reached its full depth, so this one may be an Archimedean spiral up till this point and after that it can have a dwell period dwell period means that the radius does not increase after that okay, and when it is ensured that the full number of teeth have been cut after the end of that there will be a rapid fall okay this is the total rise of the cam equal to the full depth.

There will be rapid retraction if it is you know pressed by the help of a spring if it is pressed with the help of a spring it will rapidly retract and, take it away when this particular section radial position comes here, so throughout the cycle of the cam we can have an in impede like that if time permits I will incorporate some small numerical problems on this one, so with that we come to the end of the 12th lecture thank you very much, we will again take up this discussion with some numerical problems in the next lecture thank you very much.