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Course
On
Spur and Helical Gear Cutting

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Lecture 15: Gear Hobbing-I

Welcome viewers to the 15th lecture.

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Of the series foreign helical gear cutting last time when we met for the a this series of lectures we were discussing about ear shapers, and we solved some numerical problems and multiple choice questions regarding gear shippers, so incase of gear shapers we have discussed about spur gear cutting about locations of gearboxes and calculations of gear ratios and several multiple choice questions on different aspects of the problem we also discussed that this one moment.
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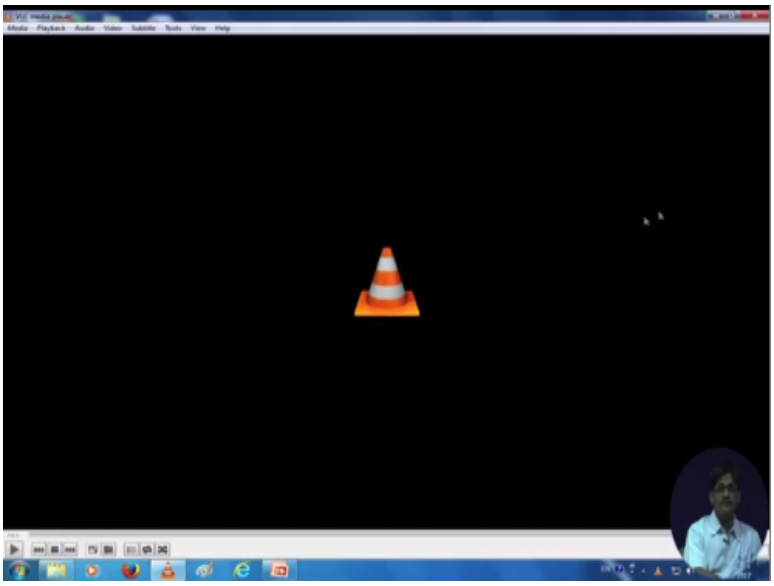

About certain machine elements of which one of them I would like to show here this is a spline shaft with some gears mounted on top see it is rotating location wise they are moving together but the moment, you move one with respect each area see actually they are movable with respect to each other these are called the spline shaft just a moment can we have it once again yeah let us see the axial movement is you know one is free from each other but rotation wise they are locked with each other if one has to rotate the other has to rotate with it okay.

So I will try to upload several of these clips without including them in the lecture because lecture time is precious for us only 10 hours of lectures do we have, therefore several clips I will try to you know collect together and put it on the forum, so that everybody can open them and see them active during your spare time so to start it once again let us move back to the start of the 15^{th} lecture so at that time we were discussing what about helical gear cutting in case of shapers in case of shapers vision at one pitch.

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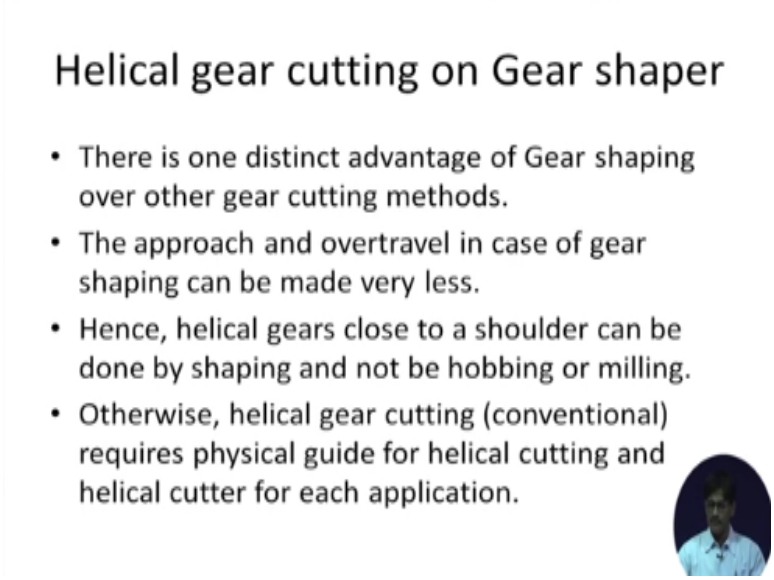

What is the advantage, advantage is that in case of gear shaping we require every little approach and over travel, so that means if you have a look at this particular figure.

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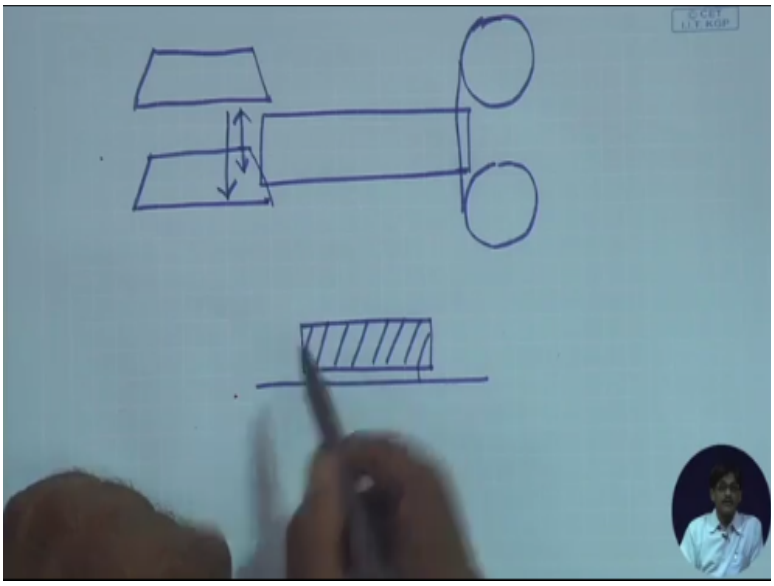

Suppose there is one gear this is the blank and you would like to have movement of the cutter from basically, this point to this point the cutter cannot move beyond so in case of that the gear shaper cutter is you know, quite useful this is the gear shaper cutter and it can move from this side to that side. Okay just this much motion is sufficient for us on the other hand so that that means it is reciprocating if we if you kindly remember it is reciprocating but if you have the hob cutter we will come to the hob cutter or the milling cutter it has to start from somewhere here and it has to end up somewhere here.

That is it has to move through this particular tooth and hence if you have a configuration in which there is a gear right beside a shoulder, so this is a shoulder and there has to be say helical teeth cut on this one you have a problem with milling or you have a problem with you know other methods of gear cutting but in case of shaping you can move this way but in shaping the problem is the cutter moves up and down in this manner, okay and for that you need a physical guide you need a different type of cutter and all these things add up money-wise they become very expensive.

So that for a particular Helix angle if you require a particular cutter and a particular guide mechanical guide it becomes a king's ransom, okay to have the full set and that is fine then we discuss gear hobbing especially the aspect of helical cutting of gears during that I will make a comparative study, so that you will be convinced yes for helical gear cutting gear hobbing is the

answer okay gear hobbing is the answer not gear shaping so this thing we have already discussed so let us go back.

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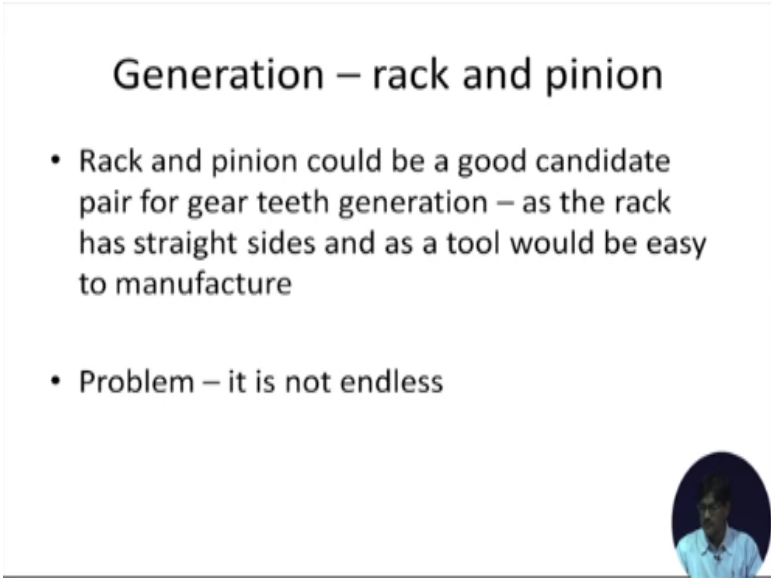

So let us come back to generation we were discussing about generation and with respect to generation we have already had a discussion on gear shaping which is based on generation what does it utilize it used utilizes opinion cutter that means a cutter shape it like a gear okay and it is rolling against the blank and ultimately converting it to a fully made functional gear, now comes the question that in that particular gear cutter that means shaper shaping machine gear cutter there is still one problem what is that let is have a quick look at that.

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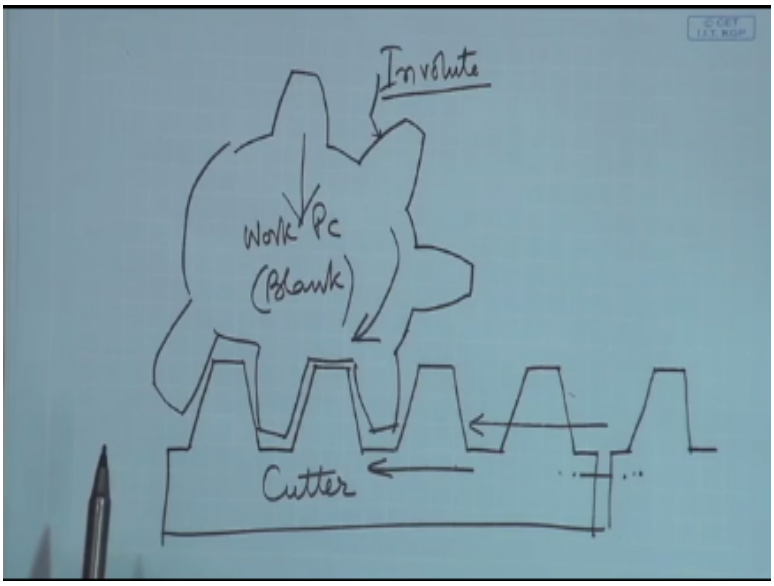

In this field the shaper cutter is going to have the exact profile of a gear of that number of teeth those many number of that many number of teeth and that particular module, okay so that means this particular profile has to be an involute say in case of involute gears so a 20^0 involute, so the problem still remains to some to some extent if you are interested to cut gears by gear shaping you have to have a cutter which has a perfect and complex curved form which are difficult to produce okay.

So we are talking about difficulty in producing complex curved surfaces and that is exactly what we are coming across in case of gear shaping the pinion cutter has to have a curved periphery it has to be extremely accurate because it is giving rise to you know subsequent gears from the blanks, and therefore we still have a problem we have to manufacture this particular complex profile so that immediately gives us an idea that if we consider the basic rack which is fitting with you know these teeth the rack has an advantage over this if we can have the cutting element in the form of a rack.

It is going to have a very simple profile okay this profile is going to be extremely simple it is a straight line okay it is angled but how does that matter it is a straight line it will be easy to produce this okay but the problem is if we make this particular see this gear is meshing with this particular rack and again we have a problem what is that problem.

If we make this cutters and if we make this the work piece that means a blank which is getting machined into the form of a gear then of course we will be giving providing all the motions this

is rolling against this one these two motions obviously have been provided the rack has to move up and down you know that rectification etcetera and all the other things like this has to have radial in feed and this has to have the relieving motion all that can be provided.

But the main problem is that while the rack is moving from one side to the other since it has to be a finite length at one time you will find that there are no more teeth left on the rack it has moved completely to this side okay, this particular border has come to this particular portion and there are no more teeth left on this side, so in that case there are solutions like in the rack cutting attachment sorry, there is most relief I remember 30 Matheson's gear shaper with a cutting element as a rack okay.

You can have it mounted on a chain so one after the other these are coming and then they are you know getting re-circulated okay, the problem is it is not one complete rigid body and therefore they will be will be subtle changes in position which will give rise to errors. So these errors gives rise to in accuracies in the work piece and that should be by all means ever avoided, okay. So how can we have a rack which remains you know always with available teeth for cutting yet it moves just imagine endless rack with that idea in mind?

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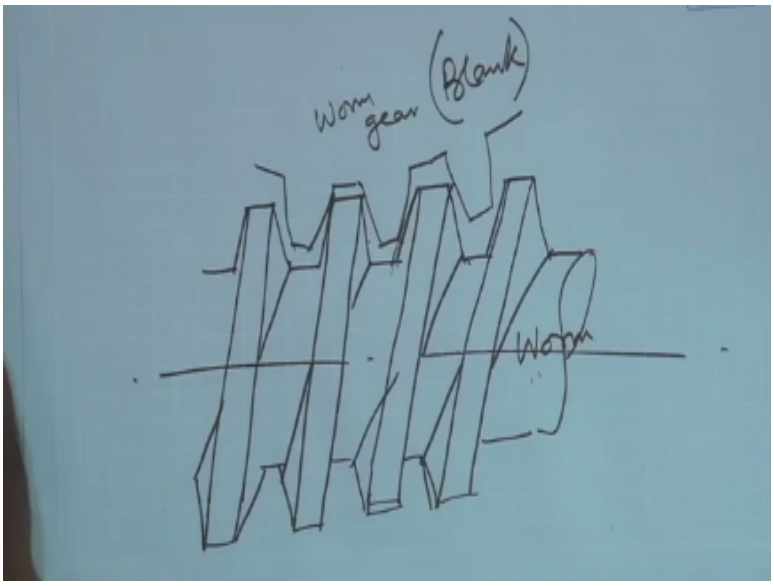

We will you know we can hit upon or rather metal cutting scientists hit upon this idea that fine have a rack have the you know virtual work piece here excreta and in order to make this endless why do not you employ a threaded element, remember in our childhood days we used to make a very interesting game with ourselves you know you with yourself what was the game if you go on rotating a threaded member okay, this sort of a threaded member if you go on rotating this you know holding this one and rotating a threaded member it would seem as if a wave was passing from one side to the other okay.

I will I will definitely introduce a clip in which you will be seeing this you have done it so many times I am sure in your childhood days that is a threaded member then it is rotated it would appear to have a wave that means just like a rack movement from one side to the other. So if you rotate a threaded member it would be just as a rack and that for that to an endless rack connected to the work piece.

So this gives us an idea why do not we employ the worm and worm gear arrangement to act as the cutting element and the cut element okay, so this will be the worm and this will be the worm gear we will put the blank here so that a gear would be cut instead of the worm gear and we will put the cutter here which will look like a worm but we will produce cutting edges on it, so this is the idea. I wanted the rack the rack, rack as straight sides but the rack has finite length so I replace it with a screw okay, a thread threaded element with the same cross-sectional that of the rack.

So I still have those straight sides which are easy to produce and by rotation by virtue of rotation the endless rack is produced here and the only thing which is left is that I have to you know based up upon this particular worm cutting ability, cutting ability has to be given to this worm because ordinarily this screw thread has no cutting edges it cannot cut like a milling cutter so I have to make it a cutter a worm with cutting edges is called a hob and the process which follows will be called gear hobbing, so let us is have a look.

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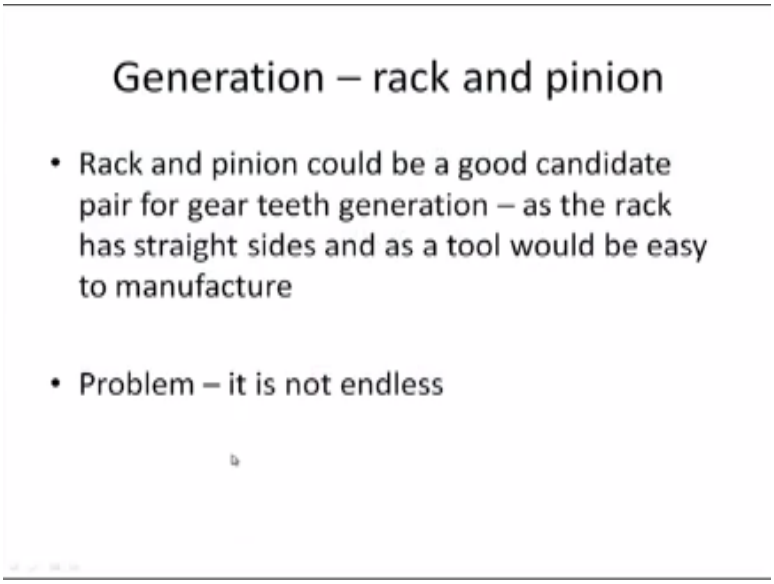

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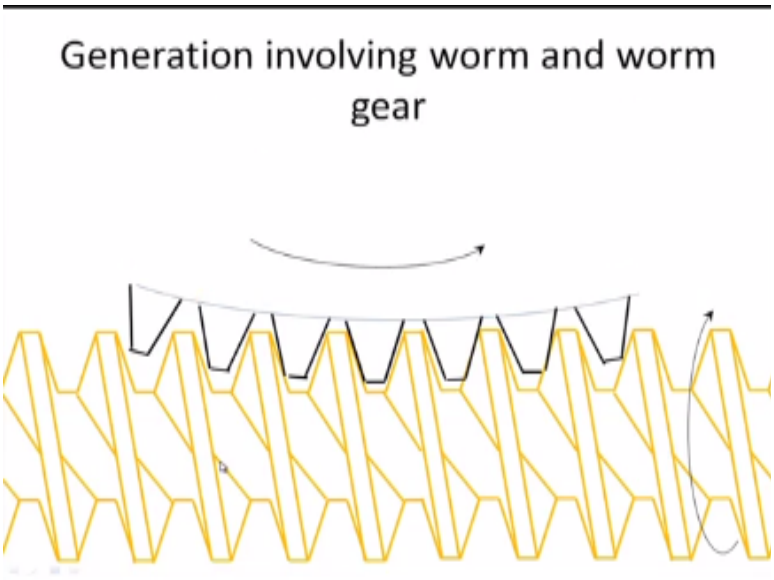

This is it okay, the blanks will be moving this way and the worm will be moving this way and this worm will be converted to a cutter by making some gashes in it longitudinal gashes.

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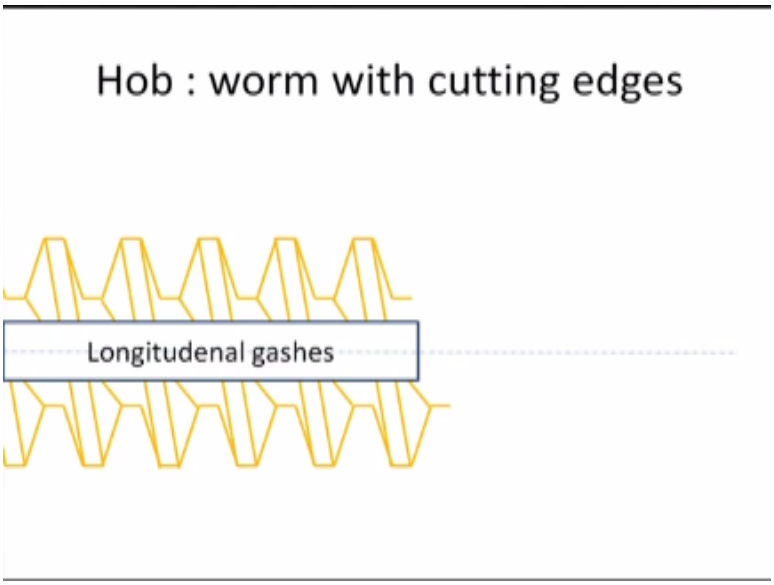

Let us see how it is, this is the longitudinal gash, longitudinal gash means you are removing whatever material is there to form sharp edges both on this side and that side, how would it look like.

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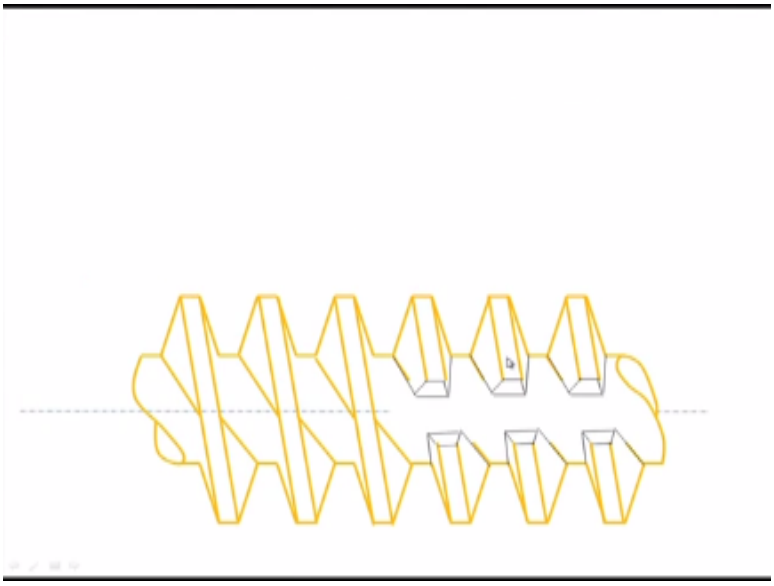

It would look somewhat like this, this is the continuous thread and this is the thread cut open and this portion is removed so that you have sharp edges existing here how does it look like from the end.

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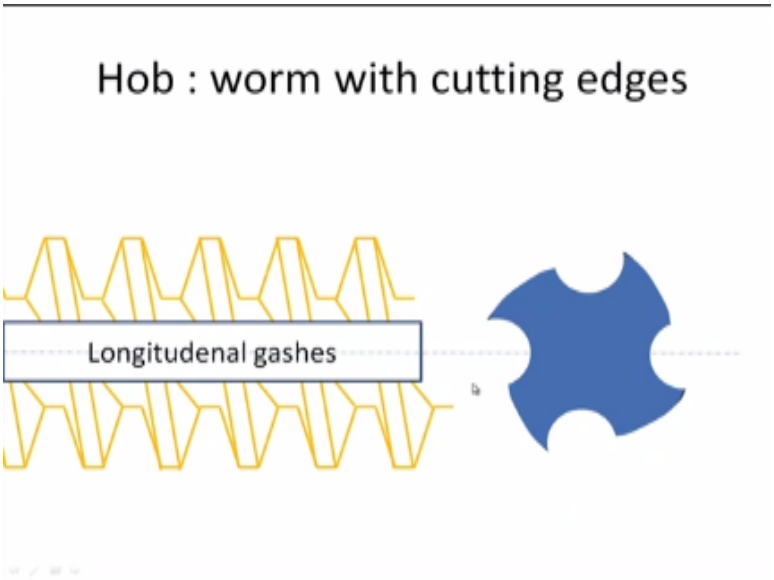

It would look somewhat like this okay, longitude gash is made here one here one there that means one on someplace here one on the other side which we cannot see and one on this side these are the longitudinal gashes that we have made it opens up cutting edges this is one cutting edge okay, a series of those interrupted teeth which are going to have sharp edges. However there is yet another thing that we have done here in order to turn it into a cutter looking like a milling cutter from the end. Let us have a look basically if you see it on the piece of paper.

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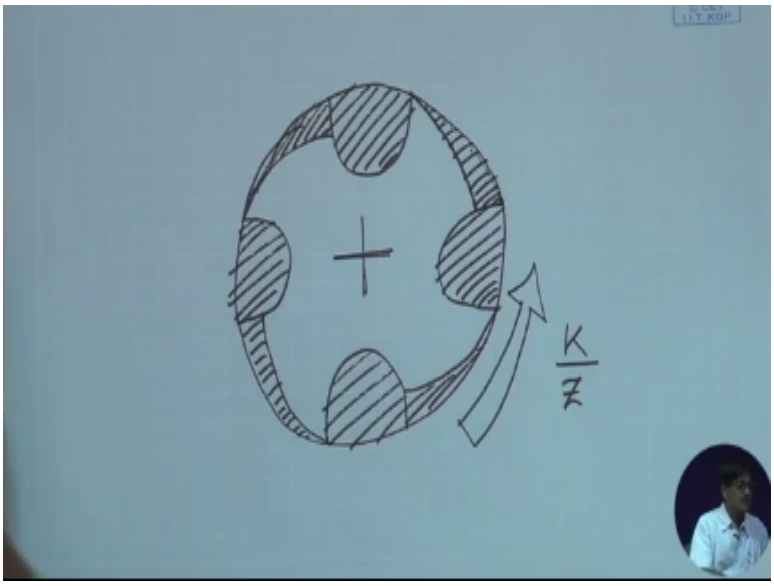

This is the worm seen from one end the longitudinal gash opens up these portions, however if you use this as a cutter there is a problem what is that problem, the whole outer periphery which is on the circumference of a single circle okay, about I mean if you rotate about this all these points will be at the same radius and if you try to cut something with this one all these points will rub against the finished surface which is not desirable, so we put some sort of you know relief here and cut away these portions may be Archimedean spiral or logarithm spiral just like in case of form relieved cutters in milling.

And now if you rotate it this way it will be capable of removing material by cutting, so this is gone this was also gone, so this makes us the particular of cross-section so it is capable of removing material now. Once we have this sort of a cutter it still maintains the speed ratio with the work piece okay that means that if you give it give it a fully formed gear it will connect up with that particular gear and establish a particular definite speed ratio depending to K / Z that K is the number of stars okay K / Z where K is the number of stars on the bomb and that is the number of teeth on the worm hear if already discussed is this so many times.

So it still has a perfect speed ratio with a fully formed gear that means if we now provide this with a speed and a blank with a speed exactly here in inverse ratio of k/Z okay and make it moved across the cylindrical surface of the work piece or blank we will get teeth cut by the method of generation okay let us have a look how It works.

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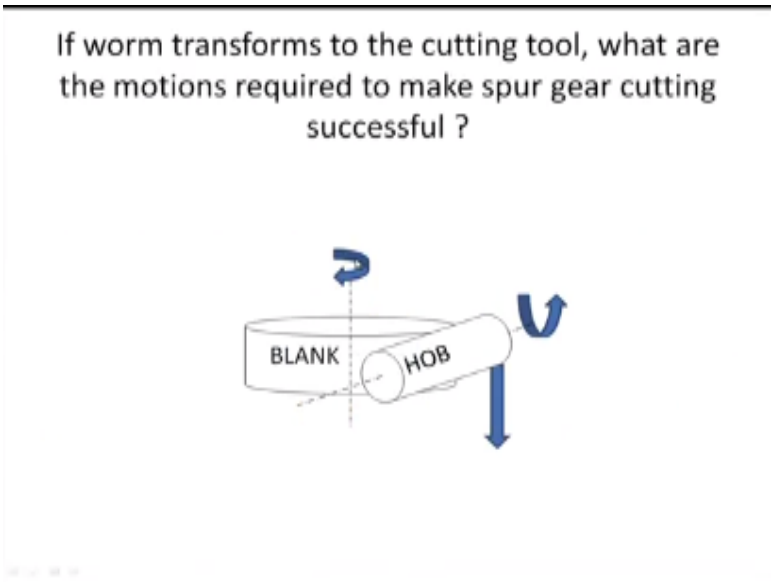

This is the figure now I have replaced the opera file by a cylinder because now you have the idea how it is made and this is the blank, so if I provide rotation as if this is a fully formed warm gear and this is a this is still a bob they will have the speed ratio that they were supposed to have If they had been form and form here at the same time I am moving the hob across the face from the top to the bottom of the blank with of course the interference that means that a depth of cut equal to the total depth of teeth in that case I will find that teeth are going to form on the periphery of the work piece.

The work piece is moving okay, and the hob is moving down very slowly past the face of the blank the blank or above these moves the hob also rotates at a much faster rate and tics is the materials from the periphery, so that you will find initially.

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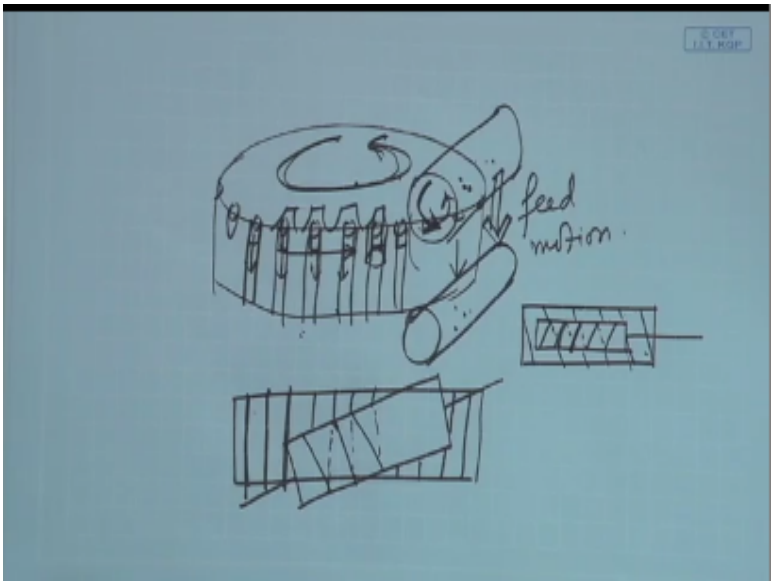

Initially if this work piece and if this leader of in the beginning okay so this one is rotating fast this one is rotating slowly and initially it will make small you know cuts on the part small cuts will appear next the hob is continuously going down and these cuts will be you know extended after a few more rotations you will find a chair the cuts are now extended this way it goes on going deeper and deeper that means down in depth and these teeth start getting the full profile this way may be up till this point first and that way.

So all of them start getting extended in this direction and ultimately they will be fully cut when the worm has further than the hob has completely passed beyond okay. So this way all of them start getting the cuts and all of them get extended vertically downwards by vertically downwards because they are exactly matched okay they are exactly matched by the property of warm and worm gear so this is removing all the material it finds on its way which does not belong to the warm gear okay just a method of generation that is it is removing all the material.

So that the conjugate profile which is formed is nothing but this particular form here in our case a fully formed gear okay, so these teeth will be formed I will definitely include a clip of this one you can see it by opening it up. So this way the you know the teeth are formed and the hub from the top to the bottom it moves if you move too fast these theta going to be rough if you move too slow is going to take a lot of time but the surface will be quite smooth, so this downward movement it defines the feed.

So this is the feed motion what about the circular motion of work piece this defines the indexing motion okay with respect to the hob speed it defines how many teeth you are going to cut remember the ratio of the cutter rotation to the work piece rotation will define the number of teeth being cut. What about the hob rotation the hob rotation defines the cutting speed okay, the hob rotation defines the cutting speed.

Now you will notice that when we are cutting a spur gear then typically the hob will be inclined at an angle okay you are cutting teeth like this and you will find that the hob is typically inclined at an angle you might say why should the hob be inclined because please remember please recall that when we are cutting when we are engaging the worm gear with the worm okay we grow figures like these in that case the form has a particular thread.

So definitely this part the thread has a particular helix angle this helix angle on the other side has to match okay this one has to match this one has to match with the teeth on the worm here so ordinarily the worm gear teeth will be slightly in kind worm teeth will be slightly inclined if they are supposed to be you know straight. So if you are interested to cut straight teeth in that case you have to make the worm teeth parallel to this direction so these are the warm teeth now like that.

So if you keep the worm teeth the teeth of the worm gear has to be have to be inclined so the worm gear has to be inclined somewhat in order to get straight teeth okay. So we will be learning more of this when we discussed helical hobbing, so we learn that the worm needs to be rotated and inclined at an angle the worm or the hob the vomit cutting edges has to have rotator motion to develop cutting speed the work piece has to rotate in order to get indexing motion and the hub has to be fed vertically downwards in order to have feed motion.

You might say is this the only possible configuration for hobbing, answer is no there can be other methods but this is one of the most common methods by which hobbing is done. Now let us have a quick look at the configuration that means the machine layout what do I mean by the machine layout just as before when we were discussing shapers we noticed that incase of shapers you have to provide the machine with a certain amount of versatility.

So that not only can it handle different numbers of teeth it can be run at different values of cutting speed it can be run at if it can be run so as to provide different numbers of teeth and it can

be run so as to provide different you know surface roughness values in energy it can be done to impart different surface finish values on the work piece surface. In order to provide that versatility we incorporate gearboxes with the help of which you can have different values of these parameters cutting speed number of teeth surface finish and of course at the final stage different helix's angles.

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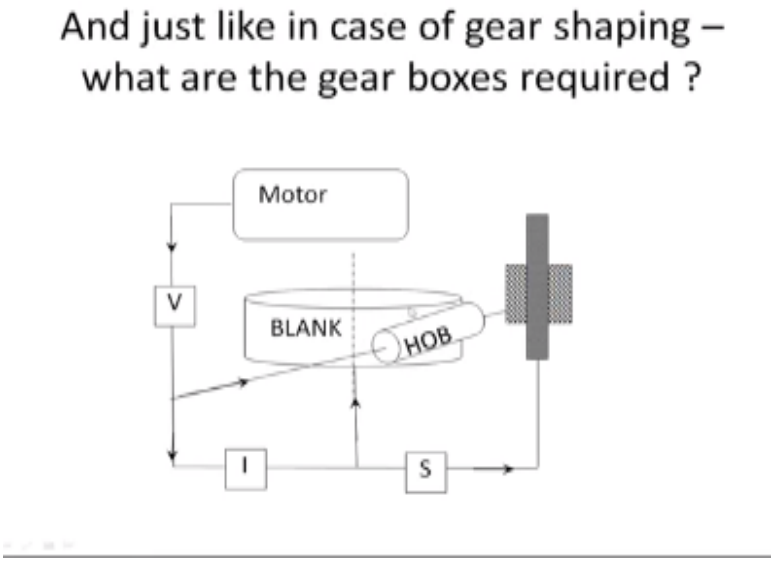

Let us see the next one this is the configuration which is proposed for the different gearboxes, so first of all this is the preliminary case in which up till now we are not considering a helical machining that means cutting of helical gears. So what do we have here to start it we have a single motor from that single motors we are having the speed gearbox, so please note instead of writing UV as the gearboxes are represented by very small boxes we could not accommodate UV so we have written V.

So V stands for speed gearbox i stands for index gear box and S stands for feed gear box as we have discussed in case of shapers the gearboxes have the same function UV supposed to control the cutting speed UI is supposed to control the number of teeth being cut Us supposed to control the feed in millimeters per revolution of work piece that means how many millimeters of improvement will take place vertically downwards by the time that the blank rotates one okay.

So we understand that there are three gearboxes and these three gearboxes are having these three functions now once again just like shaping machine I mean gear shaper let us have a quick look

whether the positions that we have suggested for these gearboxes whether these locations are unique or there can be other configurations also which will serve the same purpose.

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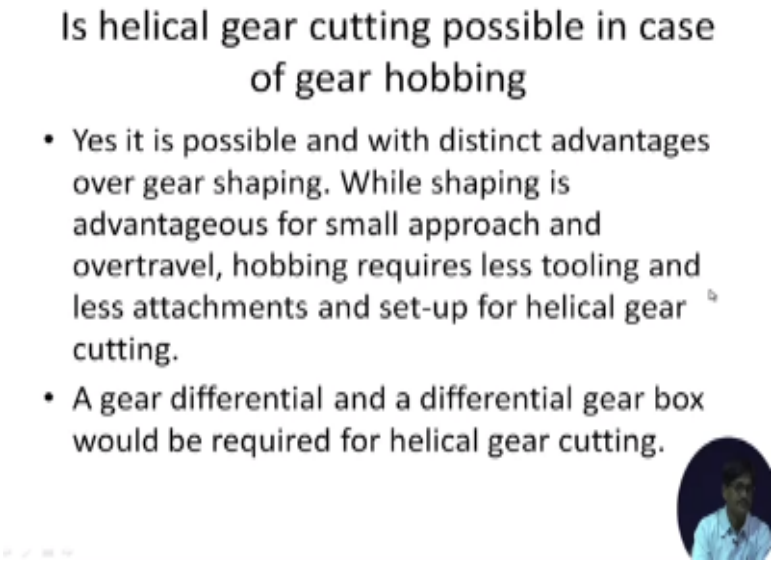

So what is this where we will come to this one a little later, so let us see this is the position that we started with and I am taking a different configuration.

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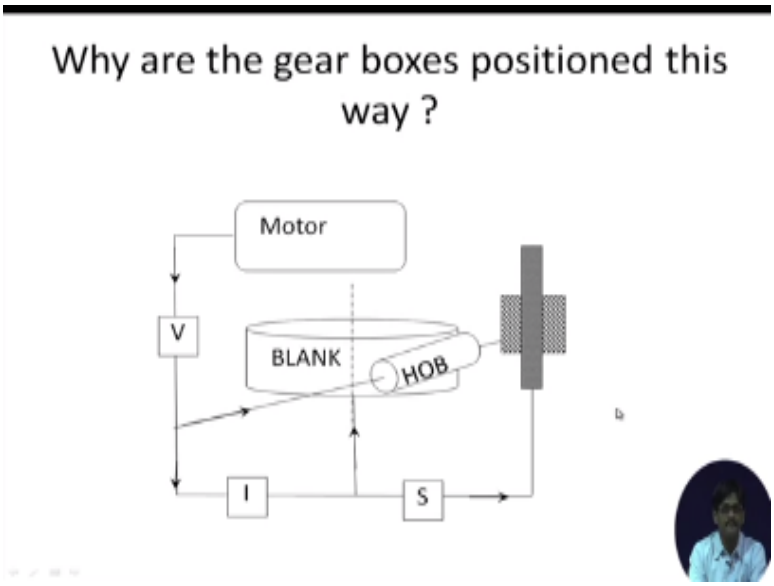

If you remember the simple rules of a being that he had sorry simple rules of gearboxes that we had you know stated and accepted the large plate it was that the change in one gearbox should only affect the parameter it is intended to change it should not affect any other parameters okay. So it means basically one year box then it is changed it should affect only one parameter and it should not affect other parameters okay.

So with that in mind let us have a look at this particular configuration what has been changed here I have shifted the position of I from this point to this point what is I supposed to do I is supposed to change the number of teeth being cut, so first of all let us first see what was the previous provision and how it was serving its purpose generally the number of teeth being cut will be decided by the RPM ratio of the home and the blank.

So let us quickly see what are the machine elements which are in that particular loop so starting from the hob rotation I start from the hob rotation here always rotating okay and then this is the part and the blank is rotating okay this is the part if anything lies in this path if it is changed it is it is going to affect the rotational ratio between hub and the blank and that will change the number of teeth.

So if you look at the previous case in the previous case also I was there in the loop and in the present case I still there in the loop only it has shifted from one position to another let this one and this one okay these are the two locations that we are talking on so we are saying this is sorry we are saying this is acceptable while this is not. So let us see what is going wrong here if I is placed here and suppose we change the value of I to get a different rpm ratio unfortunately as it is just ahead of the hob it will change the RPM of the hob as well.

And you start getting a different cutting speed and that is not acceptable as it is going in the basic law of you know mutual mutually exclusive function of gearboxes, gearboxes should function in a mutually exclusive manner so that is being transgressed okay so this we come to the end of the fifteenth lecture we will again take up the same discussion that we will pick up the threads in the next lecture, thank you very much.