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Course
on

Spur and helical Gear Cutting

by

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Lecture 03: Gear Geometry

Welcome viewers to the third lecture of this is spur and helical gear cutting okay.

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So last time in the first two lectures we have discussed at length some of the calculations of gears which involved module, which involved number of teeth, which involved rpm etc. And we had introduction to gear trains, worm and worm gears, then rack and pinion and after a bit of discussion on spur and helical gear geometry which we will be continuing today. And also we have done some very primary calculations in order to find out rpm or find out gear issues etc, etc.

So today we will take up the loose ends that we left off in the last lecture and continue with our discussions on geometry of gears so that it will be easy for us to take up calculations for actual gear cutting practice on machine tools.

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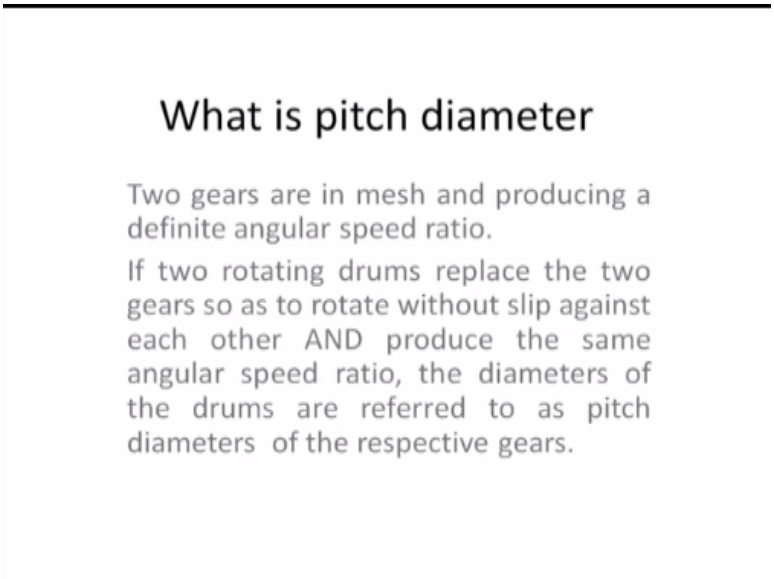

So to start with we have discussed about the pitch diameter. What is after all the pitch diameter. Pitch diameter is a virtual diameter like physically it cannot be tangibly identified on the gear that means a gear if we say that what is the outside diameter of a gear you can actually pin point it out, yes this is the outside diameter which is existing the pitch diameter definitely does not exist.

So suppose two gears are in mesh and they are producing a definite angular speed ration that means there is a particular rpm ration, rotations per minute ration existing between two gears as they are rotating. So this ratio is not affected by the speed values that these gears take up, that is if I speed up one gear the other gear will also speed up if I make a one gear slow, the other gear will also become slow.

The thing that will remain constant is the speed ratio. In that case if we replace the two gears by two virtual rotating drums okay, rotating against each other without slip and replacing the two gears and reducing the same angular speed ratio that means rpm ratio or speed ratio in that case the diameters of those drums would be referred to as the pitch diameters of the respective gears.

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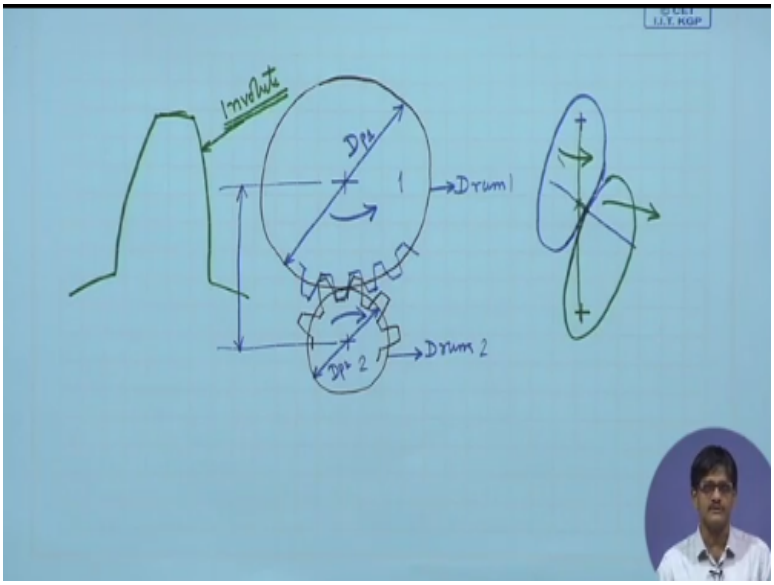

Let us have a quick look at a depiction of this diagrammatic depiction of this particular case, say this is one particular gear and this happens to be another one. And the teeth which are existing on these gears say this one is this way etc, and that one is that way. Let me take another color and this gear is having its teeth this way. So first of all physically these two gears are existing as that two-third profile, this one is physically existing okay.

This one is also physically existing, now we are making them rotate together say if this is the driver, this is the driven they are rotating we now replace them with these two rotating drums or disks. So the restriction is that this will have to be in contact with that one, that means the center distance okay, the center distance which the two gears were maintaining before the centre distance will have to be the sum of the two radii of the drums some of the radii of the two drums.

So that they will always remain in contact and one would be driving say this one is rotating, this will be driving, this one by friction without slip. In that case if the rotating disks produce the same rpm ratio as that obtained by the rotating gears in that case the diameters of these two drums would be referred to as the pitch diameters of the two gears. So this is what is our definition of pitch diameter.

Why do we bring in the idea of the pitch diameter because it make sense our calculation very simple. We do not have to think of instantaneous points of contact which might vary with time and the instantaneous contacting radii might be different at different times we do not have to

bother about that. Now you might raise a very pertinent question that if the point of contact is shifting and it moves either this way or that way the instantaneous contacting radii we will be different.

Then how come they are going to produce the same rpm ratio now in this case there is a law of gearing which says that if any two smooth profiles contact each other okay, so that the common normal okay, this is one profile rotating about this point I have drawn at irregular profile to emphasize the point that need not be very nicely shaped surface, but this profile is important. And if there is another profile this one is driving and this one is getting driven, and they are undergoing contact here, this point of contact is varying.

But if always the common normal to the point of contact always cuts the line of centers at a definite point, in that case we will find and the speed ratio will remain constant. So we choose gear profiles in this manner that means gear tooth profile, when we are talking about gear tooth, you might have seen that it looks somewhat like this. And this profile is very important. Now when we are not knowing much about gears we might be thinking that maybe they are parts of circles or they are aesthetically made or they have come down to as you know through evolution of cog wheels to give us a definite shape not really so, they are coming from this case.

Those profiles which satisfy this condition can be used as the profile of the gear teeth here. So naturally what are these particular profiles, one example is the involute, if we get time we will discuss more about the involute. But are there other profiles also, yes cycloids, the cycloidal gears are there. But you will find in most cases we are using the involute fine, because the involute has some advantages which are not available with other methods.

Other methods have gear respective advantages but involutes advantages proof to be, you know the winning factor for it. For example, in case of the involute if the center distance slightly changes the speed ratio does not change. Now what is that, it means that say you are having automobile gearbox. In a car you have a gearbox with the help of which you can change the rotational rate of the wheels okay, even though you are not doing anything with the engine, there is a gearbox in which you can have different output rotations per minute which is ultimately given to the B.

Now in that case it is quite, you know obvious that the car when moving over road might be facing lots of jerks and impacts and there is a possibility that you will be, rather the gearbox will be experiencing lots of jerks due to which the centre distance of some of the gears might be changing. The involute is not affected by this particular distance change of the, I mean the center distance change.

So we understand that this particular profile can be different types and involute is one of the most popular ones. So let us now look at a little more detailed, you know dimensions and nomenclatures used in connection with spur gears.

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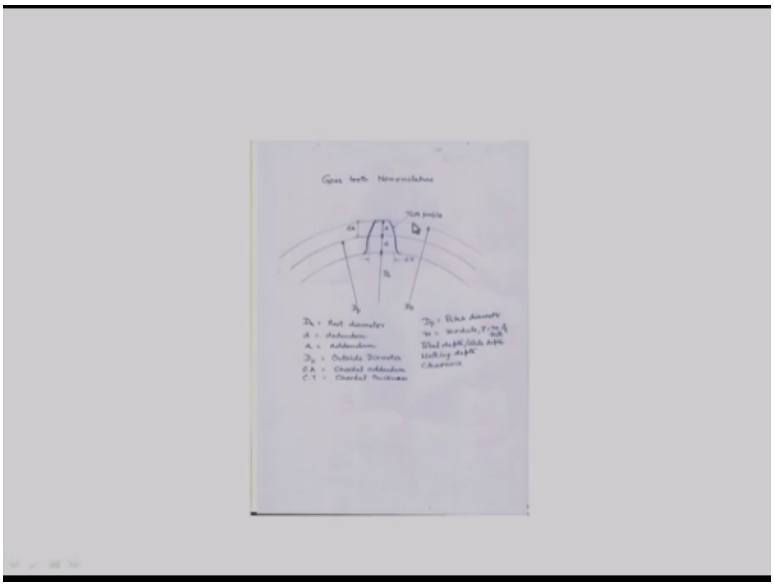

This figure is not so large, but I hope you can follow it. For example, let us look at first of all what is drawn on the piece of paper. We have a gear tooth shown here, the gear tooth is having an outside diameter, it is having a pitch diameter given by DP, DP is the pitch diameter. It is having a root diameter given by DR okay, it is having other things like chordal thickness CT, it is having something called A addendum, and it is having something called D dedendum, and it is having

chordal addendum and addendum seem to be very close to each other, we will see what is the difference.

And what do we know about this gear, see in this example we know the module and we know the number of teeth, can we find out all of these values from here, and of interest would be our total depth or whole depth which means addendum plus dedendum the working depth that means the maximum depth up to which it can go in a meeting gear and the clearance that would exist between the two teeth in that case. So let us take them up one by one. So starting with let us now look at the piece of paper starting with outside sorry, pitch diameter.

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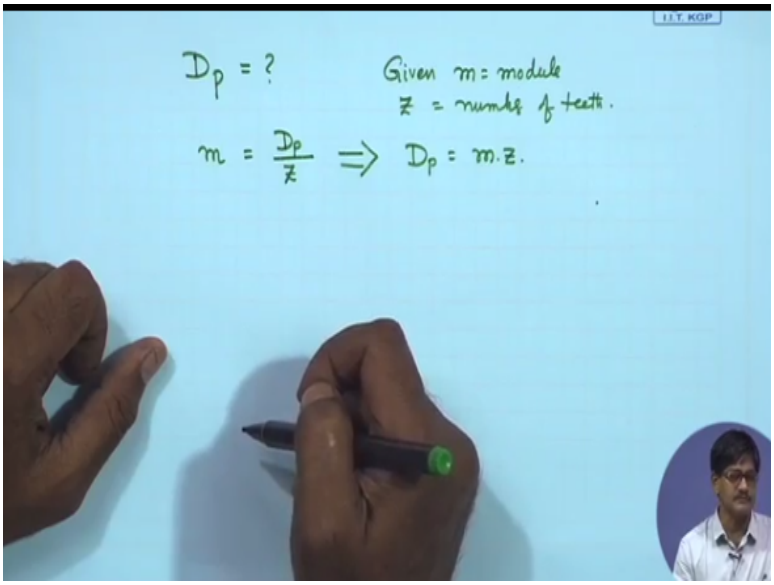

Pitch diameter has to be found out and what is given, m=module, z=number of teeth, this is straight forward we have the definition of module as pitch diameter divided by the number of teeth okay. Therefore, pitch diameter is equal to module into Z, I can find out the pitch diameter if given the number of teeth and the module. Then I find out the outside diameter, now let us go to the figure once again.

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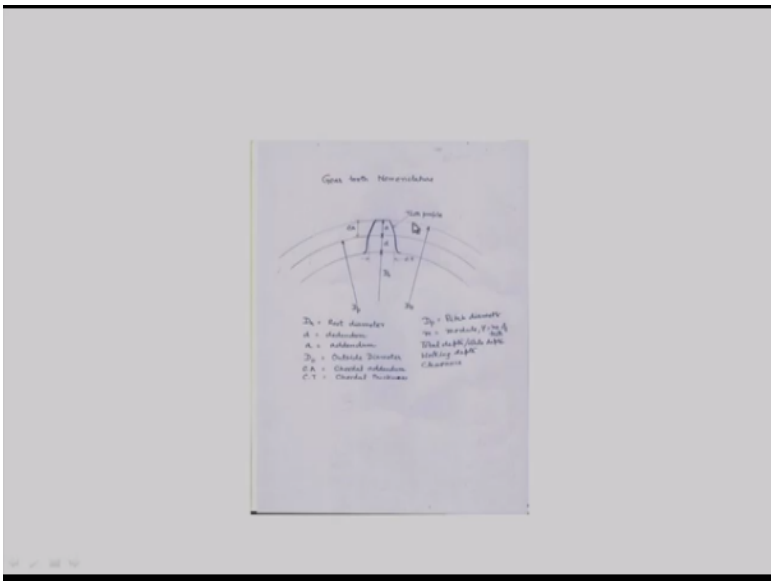

The outside diameter is shifted from the pitch diameter by addendum on this side and there will be another addendum on the other side of the gear okay.

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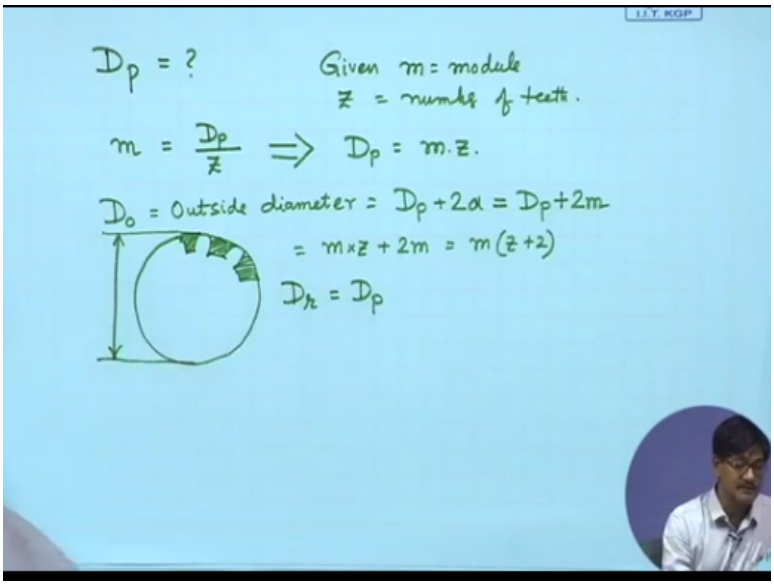

So we write that outside diameter, we come back again to the paper now, outside diameter = pitch diameter + twice addendum now what is the value of addendum I do not know that. Well those people who have been specifying gears have been a very simple type of relationship that is addendum is equal to module. Therefore, it might be slightly different in special cases, but in a most general case.

Pitch diameter + twice module that is it, we get outside diameter. How is outside diameter, you know necessary what is the importance of the outside diameter? Well, when you are cutting a gear you start from what is called a blank from this blank I mean if you are subtracting material and attaining a particular shape you will be removing this material, these amounts of material would be removed, and you will be ultimately getting the shape which results from it.

Hence, the blank diameter okay, the finished blank diameter which you ultimately start cutting of the tooth spaces that these are called tooth spaces, these will be cut off, so the blank diameter is required, so that the machine operator can check and ultimately start on that directly. So blank diameter that makes very relevant, pitch diameter which is found by mZ so here we can put in mZ let us see what it gives, mxz+2m therefore it comes out to be mxz+2 that is it.

Now comes the question of the root diameter, what is the root diameter like, the root diameter is equal to the pitch diameter let us come to the figure once again okay.

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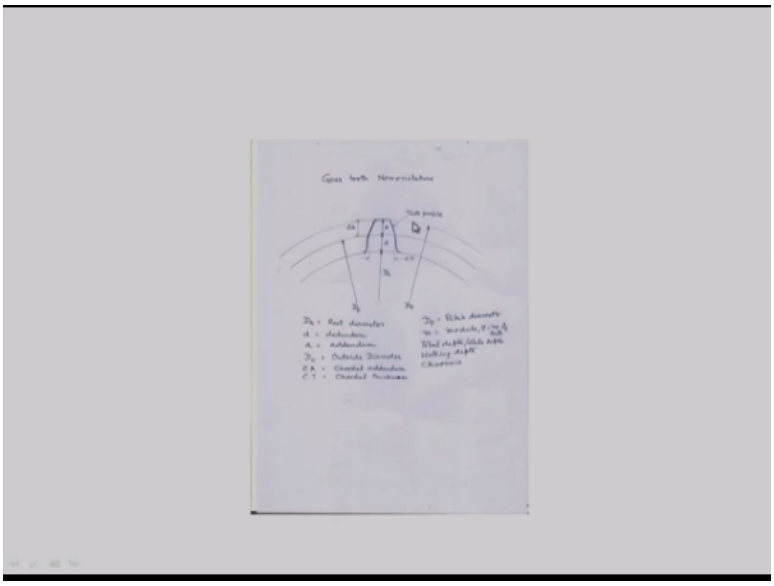

The figure you will find the root diameter is related to the pitch diameter by subtracting dedendum on both sides, dedendum here and dedendum there on the other side of the gear.

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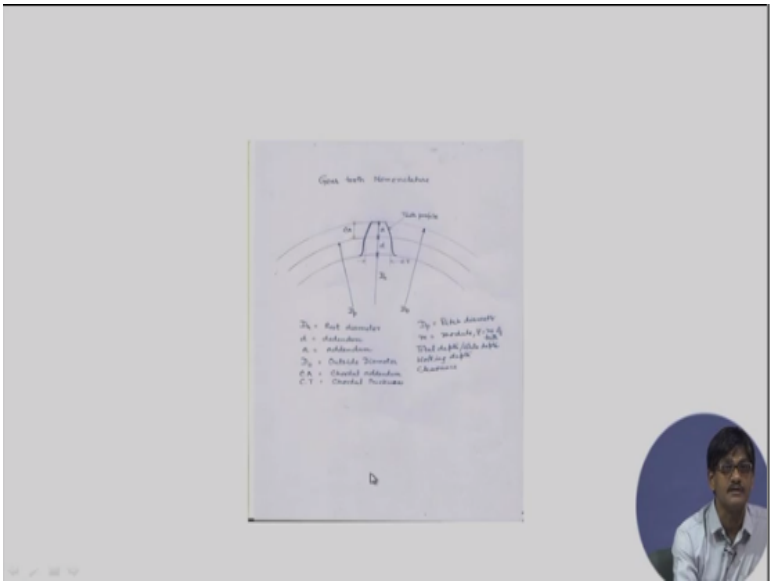

So let us write down minus twice dedendum.

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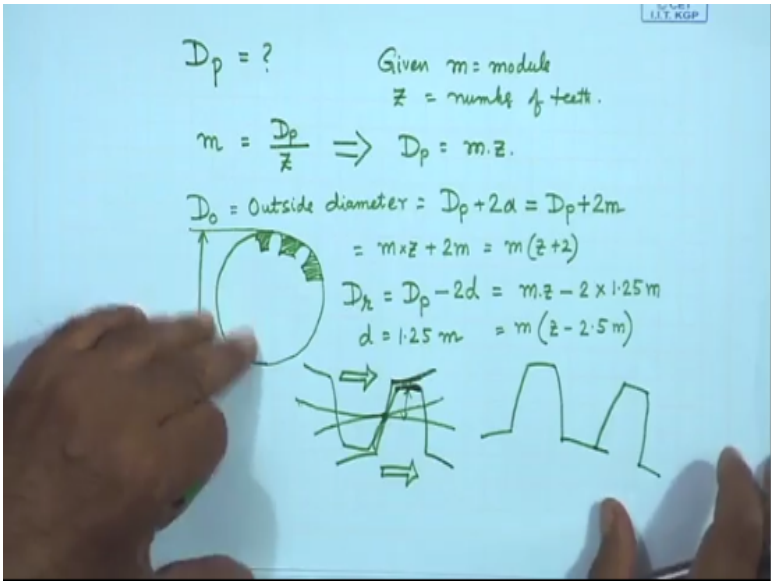

Now what is dedendum maybe it is equal to module no, dedendum is equal to may be its equal to volume no dedendum is =to 1.25 module .so lets us write it down you might ask why is this so, because needle it should have been w =to module 14 following the definition of agendum it is not so, because we want some clearance to the exist between gear teeth when they are in the mesh whatever mean by this .but before that, just write it down m*z _, just a moment 2*1.25 module.

So module can be taken common z_2.5 module. Now why is this so? So far that lets see a figure this is one gear and this another gear tooth coming in contact with it, may be let giving prevent ,so this is rotating this way this is rotating this way so these two gear have a contact here and say some where this is the edge diameter ,this is the edge diameter of this one ext.

Problem is from the edge diameter this one gear has one depth to dedendum and this one gear the pitch diameter has a depth of addendum .if addendum and dedendum had been in the same ,is the addendum and dedendum is the same ,if thus case they would have been contact in the some cases between this surface ,that means the outer outside diameter ,cylindrical crown surface and the root diameter cylindrical crown surface ,these two have got contact ,this would have wound not have given the speed ratio that is existing between these two gears the speed ration the existing between these two gears is defined by the contact between these two modules.

Dr =to modules is simplify by the diameter ratio and these two diameter, is definitely, not only the same ratio as the pitch diameter ratios. So the ratio of the speed defined by the two pitch

diameter is not be realize and contact between these shoots these two should never get in touch within each other ,so provide the clearance in between which is 2.5 module ,that is why dedendum is larger than the dedendum.

These are the gear teeth can never contact with the roots of the other gear okay. so now we understand ,why dedendum more than the addendum and what is the expression of the root diameter and what is the of the outside diameter etc. now let's look at some other ,and what is addendum and what is dedendum? You might say is addendum proportional to the module, let us look at the gears, now if this wheel, gear how it module affecting its shape or size, let us take a fresh piece of paper.

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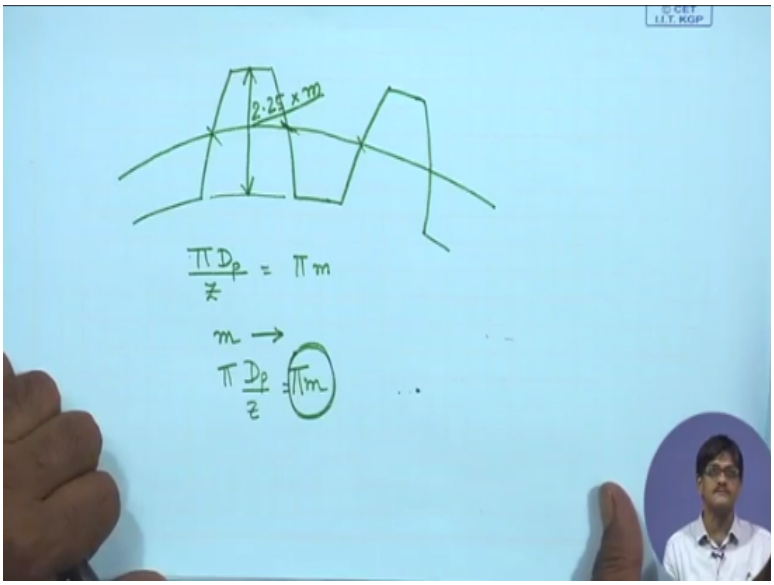

If this been ,how it is module s affecting shape or size ,we find that if we draw the pitch circumference from here to here okay ,this distance is called constant for all gears having same module. So the module defined this distance on this all the gears having in the same module, so this distance=to π **d** $_p$/z okay. It is relevant to the gear teeth by this dimension, and it been assumed that these two diameter, mean this is =to this one is equal to properly defined by module once it will be the module ant the number of teeth, I can perfectly defined this I can exactly defined how much this should, if that we show that means the weight of the gears ,they are defined by the module and the number of teeth..

Sorry ya that is the number of teeth, .so if we not ,not just a moment we should say that whatever be the ,this =to π8to module that we can say ,should correct the particular statement ,if the module is given okay, if the module is given ,we can say this distance will get defined if the module enough number of teeth ,number of teeth will not adding these distances to the circumference ,so if the module is given this thing get defined ,so the weight is defined by the module, this should be proportion to it .and from it the idea and the dedendum an sliding up more slide is 0.25 and that is why this thing become 2.25 into module.

It is the proportion to the module and why is this distance only dependent upon the module because since you know DP/z =to module, .this distance is is nothing but * π .so it is fully defined by the module, this distance is fully defined by the module I made and mistake its ,we need not dependent on the number of teeth ,but it fully dependent on the module .

And we simply make, now that the gear is nothing but the with is defined as by module is nothing but the module, is defined by high week proportion to it, this one has to slightly more and fore that will come to 2.25 module you might say that exactly =to module 0.75 module or 1.25 module .those gears also are available like is 0.8 module which are called stub teeth etc.
But the most widely used one is the simplest one, and the equal to addendum and equal to module. So once we understood this, let us move on to other definitions which are present here .for example.

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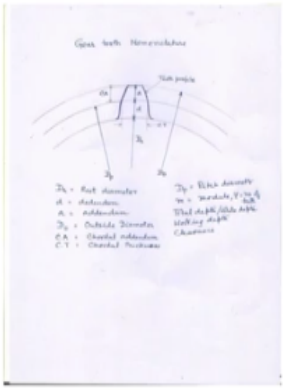

You will find in this figure.

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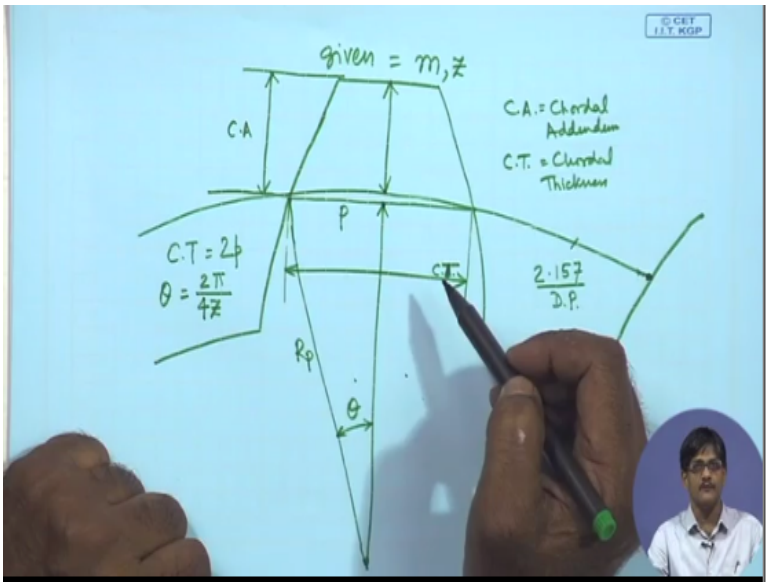

If the larger deflection as one, if this is one gear tooth you will find in that on the pitch diameter we have find that we deflected to dimensions small have been called as CA, and this one being, you know joining in the straight line and this is one this is =to ,sorry, the total addendum is this one colloidal addendum ,and this is coral addendum is thickness ,coral thickness and coral addendum so these are very much relevant in the different application like ,measurement and the accuracy in the two gears and generally want to test is correct or not in the use of you know the gear tooth caliper, this is very much relevant.

Can these can be measured suppose I know the number of teeth on the module ,by the by I should mention here in apart from module you also have DP and in the case of DP ,the dimension are slightly different ,in that case the working in the total depth =to 2.157/DP just because the dap is the reciprocal of module , the units have been kept by the it comes at the denominator okay, just like so we have 2.25 module ,as the total depth in case of module here in case of DP 2.5 as 7/DP .

And the working depth=to 2 module and the working depth =2/DP .so let come back to the discussion of cordial thickness, cordial thickness can be found of this way ,if we can you know ,draw a right angle triangle ,right up to the centre ,this is the centre which we cannot see but if I see that I know this angle .

I know this pitch radius RP can I find out say if this region, lets we given it a name E cordial thickness can write =to twice P ,that we look that we find over the P ,can I find out P .yes p= to 2 π 220° /divided first of all by z. number of teeth ,this will give you for times p okay. Write up to the second time this is rising, this full angle is full Q+Q+Q this way. Join us to the centre this will be four Q. π

So therefore we will be having four To give Q, twice in to Q, so I am going to supply some of the teeth know to you so that way Q can be calculated can or calculated yes basically all problems you knowing you we will write MHz and up can be found out because m*to d p half of the rp therefore can be 2p two p can be found out this way .right once we know Once you know RP you can find out up COS Q RP COSQ =to this value and twice of the p is cordial thickness.

Can we find out cordial thickness yes this distance is =TO A in the random ad this small distance =to COSQ okay. So tomorrow next day when we are taking the sub sequent lectures we are solve the problem of this lecture.

We will solve the problem of, solve the problem of find out the problem here .C.A and CT for m=to 20 are let take large value m=to 200 sorry. Number of teeth m=to 2 m=let me write it down perfectly or look before m= to 4 and Z=to 200 find out the cordial addendum cordial thickness for m=4 and Z=to 200, why we have to inverse, because I said this will be useful in the

measurement of the gear geometry accuracy of the gear geometry after the gear has been manufacture so this will solving as an assignments.

And what we are called at solutions may be in the fifth lectures. so you can have some practice get it done yourself and then we will compare notes last of all let me just to add you might think of some problem like, if I give two gears one you having module 3 and another will having in module 4 .does it mean the larger module have the larger teeth or smaller module will have larger teeth so with this we come to the end of the third lecture thank you very much.