Gear and Gear Unit Design: Theory and Practice
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Lecture - 31
Detail Drawing of Intermediate Shaft & First Stage Gear

Welcome to module 6 lecture, that is 6th week lectures we are continuing with design of general purpose industrial helical gear reduction unit and this is part 4 and we are in the last page of that.

Last time we have shown the complete assembly view although it is not complete in the full form, but main plan view elevation and side view are completed and now we shall go for detail drawing of the components. Now, it is not possible to make all the detailed drawings and shown it to you although it is possible we can make the drawings, but within the scope it is not possible. So, I shall show you details of on sample and in that way I would say the intermediate shaft is the best one.

So, what I am doing I am showing the details of intermediate shaft and first is gear.

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So, in this lecture first of all we shall capitulate the developed plan elevation and side views of the reduction gear unit. And, then detail drawing of intermediate shaft and

including that will include the integral second stage pinion and finally, detail drawing of first is gear.

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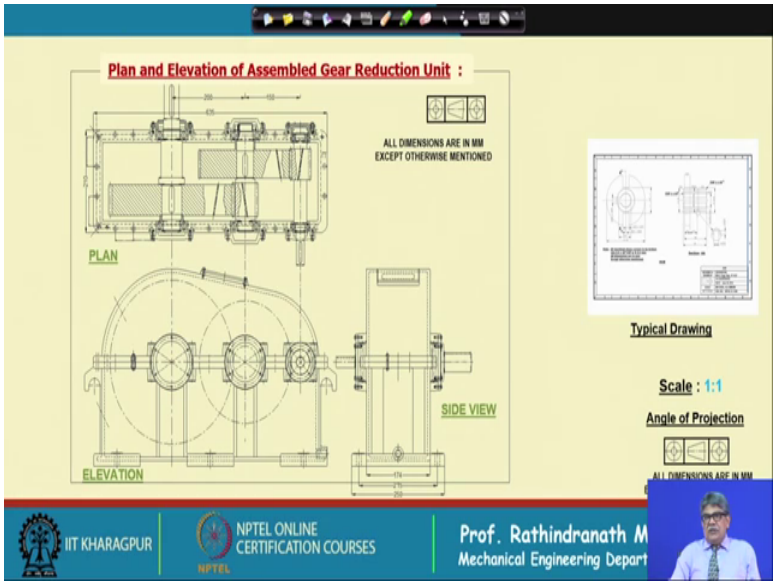

Now, this is the total view of the gear box, it is not fully completed, but still you can find that in the top left hand corner is the plan view and bottom left hand is the elevation and bottom right hand side is the side view.

This we have actually planned in such a way we have developed this is in a 0 size sheet the maximum size sheet available and somehow we could accommodate all the views there all keeping a less space for writing the nameplate another, but still it is possible that we can accommodate there, it is always better if you can present something in one is to one scale.

And we have followed third angle projection; you know what is third angle projections? If you look into this that the icon is given here. So, we have followed if this is one view the top view you can say top view or side view from this side will be this one, we are not following the nth row can put a cross over there.

And scale we have taken one is to one and the typical drawing on printing as you can see this drawing sheet, it will be something like that and it is available in the industry this means that you can develop the drawing in autocad and then that you can copy on a

drawing sheet in proper place and then it can be printed. So, that is shown here the typical drawing it will look something like that.

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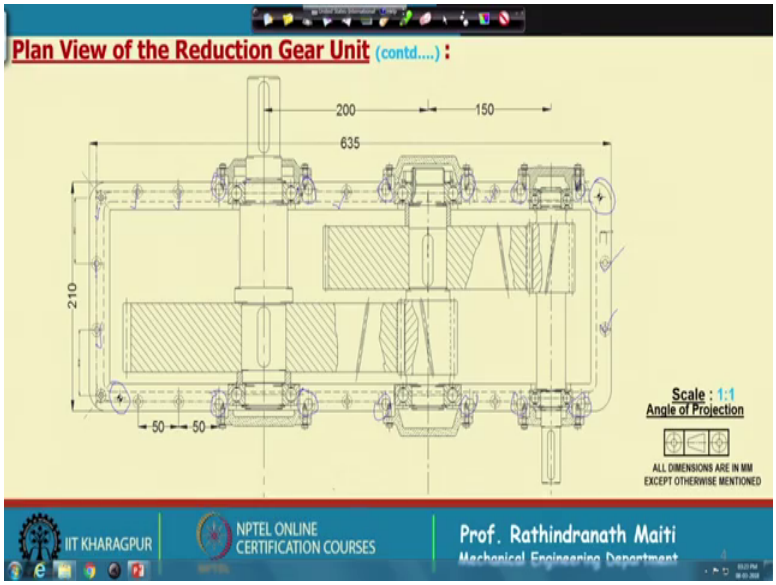

Now, in the plan view if we look into this plan view then this is the input shaft right hand side input shaft and then intermediate shaft and then output shaft. And we have also I have also given the overall dimensions, it is somewhat coming 635 millimeter long and width is not much 210 with bottom base it will be slightly more, which we can see later in the complete drawing.

But, this is a very small size gearbox if you calculate the power with nominal torque it is about 2.5 2.7 5 3 kilowatt and as there is 200 person starting talk maybe we can select a little higher size motor, but this is really a small sized gear box. And here although I have mentioned earlier, but still I would like to mention that important is that, you can see this dowel pin here, here is the dowel pin and the other corner also dowel pin is there 2 dowel pins are put.

So, that we can put the top cover properly and if you look into the bolting arrangement, then we will find there are many bolts apparently these are placed about 50 millimeter here it is a little more 65 millimeter. So, 50 millimeter and near the bearing we have put large size bolt we will put here n 10 bolt ok.

So, this will be good enough for taking all bearing loads and we have kept this bolt size the same 10 bolt size of a queue size we can put. So, totally required 12 numbers of such bolt nuts (Refer Time: 06:07) etcetera etcetera. And another issue I would like to mention here, that when we are putting this 2 covers and we are tightening fully, but still there is a possibility of leakage through that.

So, to prevent that sometimes a very thin material like a transparent sheet is put there, which practically has no dimension you can say after the pressure is put after the bolt or tighten. And alternatively some blue type materials also can be given that so, that it will prevent there is a rare possibility that oil will leakage through that and dust will go inside through this. And as you see this input and output there are although it is not shown here, but I have shown that we can use the oil seal we have to use the oil seal. So, that oil cannot go out and dust cannot come in from the outside.

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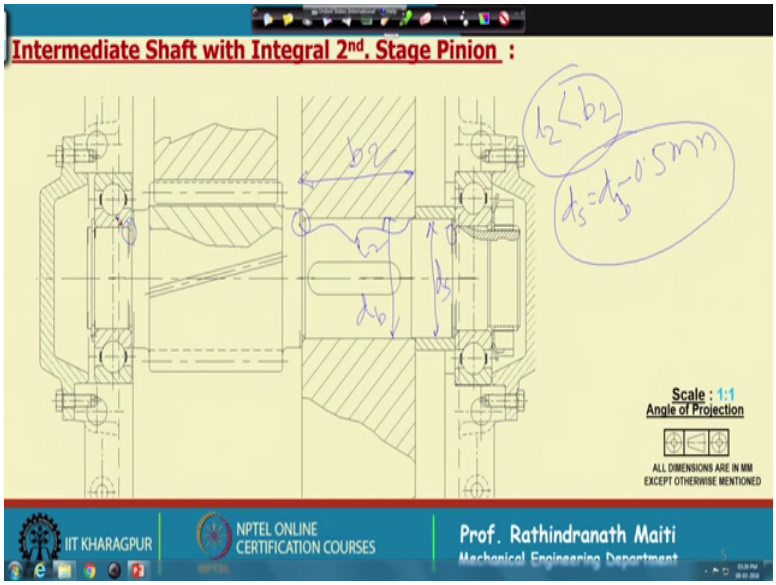

Now, here the details of in that we intermediate shaft we will make now the details of intermediate shaft, why the details of intermediate shaft? Because the intermediate shaft has no output or input right so, if we can make these with proper dimension and other things, it will be always to make the other 2 shafts drawing easy. And we when we developed the plan view, then we have taken we have put one after another and we have taken the dimensions accordingly, but you will find while we further making the detail drawing still some dimension can be altered dimension can be altered. And, then finally,

that can be put into final assembly drawing. That will not be much laborious because already it is developed with a little manipulation in the autocad this can be managed ok. So, in this intermediate shaft, what we find that there is the integral pinion is here integral pinion.

So, this is the integral pinion with the shaft and this bearing is loaded with higher radial loads, because as this is this pinion is close to this bearing. On the other hand if we look into other side bearing that will be less radial load and then we have locked this bearing fully with housing and shaft, how we have done it on the housing we have kept some rich portion in the boring.

So, this inner race left side of the inner outer race can rest on that and other side is tightened by the cover this is the cover. And again I mentioned that here maybe a themed casket can we put there to prevent the leakages. Now with the shaft how we have locked the bearing, first of all a special is required to connect the gear with the inner race of the bearing ok. And, then it can be locked on the shaft by a circlip simple circlip, but here we have used a lock nut and washer just to show normally this lock nut and washers are used with taper load bearing.

But no harm that we can use this with that one of course, for using such things we have to make a trade on the shafts and cost will be little higher than if we try to lock it with the circlip. Other ways also there you can simply put a plate here and on the plate and shaft you can put 2 bolts and that bolts can be locked.

So, that can be locked with shaft. So, we have locked this side. So, that irrespective of the direction of rotation with a an assigned helix angle the axial load always will be taken by this bearing ok. Now we shall make the detail drawing of the shaft I I shall mention later of course, but here one interesting part is that while we are putting the gear on the shaft first of all it should be tight fit it might be light drive fit by no means it should be running fit or lose fit.

And then if we think of this special which is connecting the gear side with the inner race to confirm that these will touch both the gear and the inner race without any interference anywhere. What we do the step on the shaft is less than this suppose this is b 2. So, this will be say l 2. So, it would be l 2 is less than b 2; that means; here it is a step down maybe by just by 1 millimeter from here ok.

Say d bearing and d s then d s might be simply d b by 0.5 millimeter. So, that this special can be put and this finishing here and finishing here may not be the same it is not required at all and we do not have to drive the long way.

So, for that this always when we are developing the detailed ring that we have to keep in mind. And there are also undercut needed to be provided wherever the bearing is touching with the solder or anything touching with the other component that, we have to keep in mind we have to judge we had to put the undercut.

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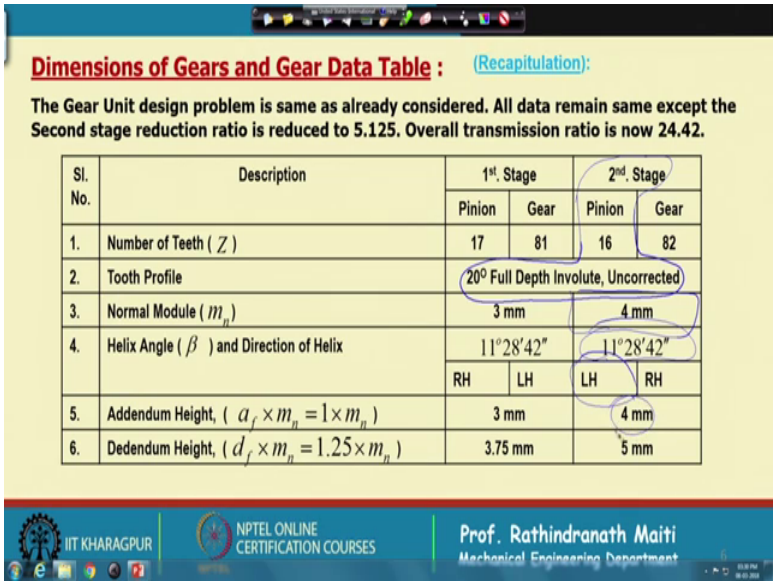

Now, very quickly we shall go through this gear data, because in this intermediate shaft this pinion is integral say this pinion we will need this data. The second stage pinion and this information will be there and then it is this module, then the helix angle, then this direction of that module this.

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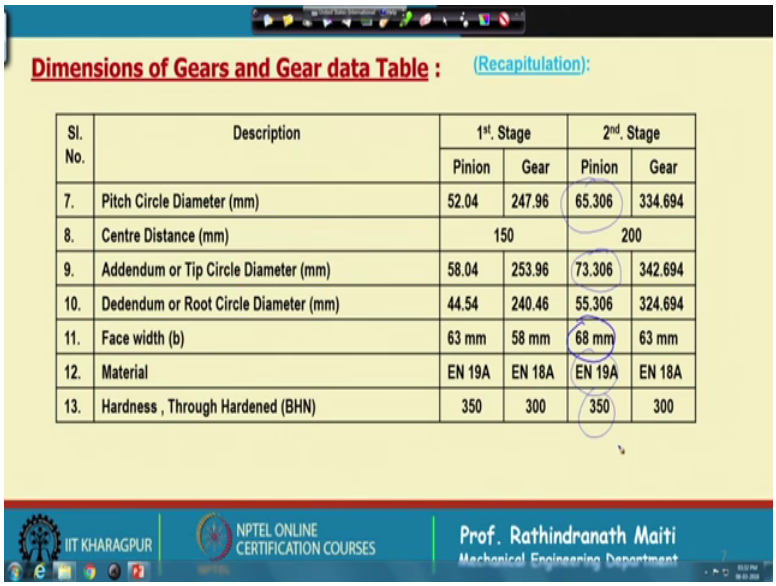

Sl. No.	Description	1st. Stage		2nd. Stage	
		Pinion	Gear	Pinion	Gear
7.	Pitch Circle Diameter (mm)	52.04	247.96	65.306	334.694
8.	Centre Distance (mm)	150		200	
9.	Addendum or Tip Circle Diameter (mm)	58.04	253.96	73.306	342.694
10.	Dedendum or Root Circle Diameter (mm)	44.54	240.46	55.306	324.694
11.	Face width (b)	63 mm	58 mm	68 mm	63 mm
12.	Material	EN 19A	EN 18A	EN 19A	EN 18A
13.	Hardness , Through Hardened (BHN)	350	300	350	300

And, next we will need that what is the pitch circle diameter we will need this one the pinion this is the pitch circle diameter and the center distance already is there we need to have the tip circle diameter, root circle diameter is not given on the drawing, because the this gear data is to be provided with the detail drawing of the gear or pinion.

So, with the intermediate shaft all these data will be provided for the manufacturing purpose ok. And face width 68 millimeter material and these all these specification, these 2 are not required for the development of the drawing; however, we have to furnish there because we have to also furnish the information about the heat treatment there ok.

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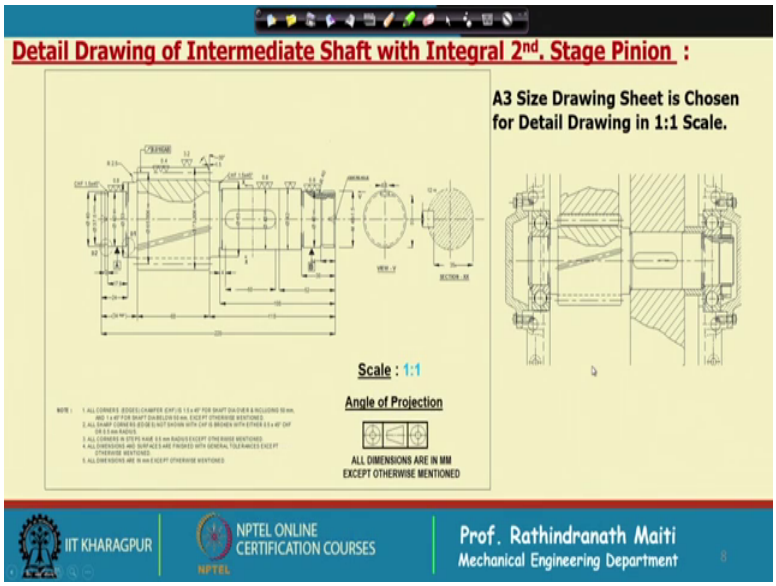

Now, this is the detail drawing of the shaft this intermediate shaft, this I shall come into details of that, but you can see this was the drawing here and this we have developed here, but if you closely observe you will find here we kept a diameter is more, but because initially we took this bearing of we took 6 3 0 9 45 millimeter later we have changed it to 6 2 0 8; that means, here it is 40 millimeter.

So, here perhaps we can reduce the diameter. So, that here at this here we get more space more solder I mean solder. So, that it can touch it we can have more area for the trust. So, this diameter we are reducing ok. So, in the detail drawing we have accommodated that and as you find we have caved here many nodes. By no means this is not the complete drawing we still really need more information on this drawing, but how we are developing this one that I will show, this is very important to know this so, what we have for this little drawing, what we have done? We have taken a 3 size drawing sheet, because if we take the a 3 size say this is the size of the drawing sheets and we can make we can put this drawing is one is to one scale, that is again better and we do not need larger side view other things.

So, A 3 size drawing sheet if we use for all component drawings that we can this is for documentation everything it would be very good of course, for that detailing of the housing perhaps we have to go for large size drawing sheet these are minor issues, but

still we can remember. Now, the scale one is to one and again third angle projection we have followed.

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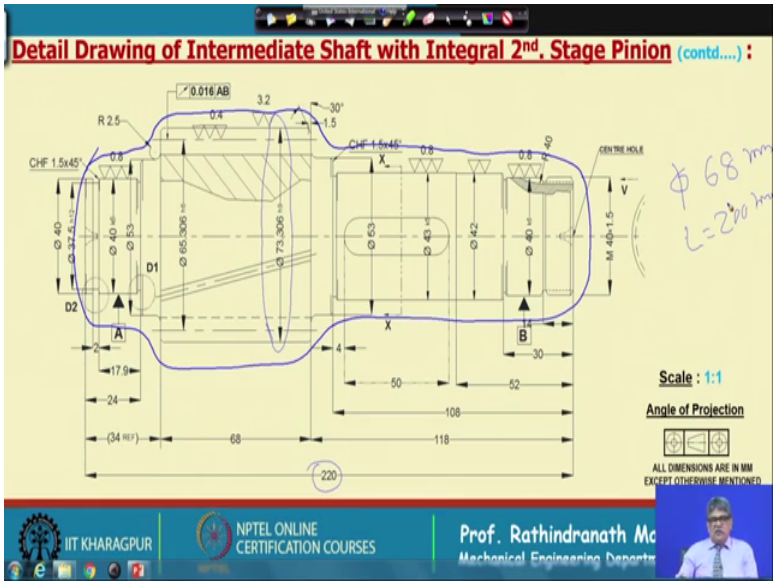

Now, here I have shown the detail drawing of this intermediate shaft. Now, I shall explain one after another how this is being developed and it is not easy even, if I explain twice thrice, it is not possible that one can learn it, in just a single instruction, he has to follow he has to remember many many things. One important issue is that while we are making the development of such detail drawing or making the detail drawing, we should have idea about the manufacturing, how will you manufacture?

Now, first of all let us consider we have we have to make only a single piece ok. This is just a job water type single piece ok. In that case what we need to do we should first of all what would be the length of the shaft. Here after the detail drawing development what we find this is 220 millimeter long. And here the maximum diameter is 73 millimeter.

So, probably if it a good stock if it is available of 75 millimeter that will do 75 millimeter e n 19 this bar is available in the market. So, buy 1 buy a piece of 220 not I will have to make a little you have to buy a little larger maybe 230 or 240, maximum you can say 10 inches 250 millimeter. And 70 if it is a good 175 millimeter we will do or else you can go for higher size probably next size will be higher size will be 80 millimeter easily available in between that it might be there ok.

So, you buy say maybe 10 inch by a 3 or 3 quarter inch a bar ok, but if it is not that if we go for mass production, then probably we can buy a this bar of say 200 millimeter length and probably diameter may be 75 or even less 70 millimeter. And, then by forging we can if we go for forging in that case we keep keeping this on forging material can be made like this.

So, this is after forged maybe the bar size age phi say 68 millimeter may be less than that notice it and length, maybe of just 200 millimeter. So, in mass production you can cut the pieces like that and by forging you can increase here and you can decrease a little bit there and you can make keeping the material for machining say 3 millimeter everywhere. So, we can make it like that ok. Next we shall think of the machining.

Now, in machining usually these are if it is a single piece then of course, we can held it in a in a chuck this length is slightly more and just by supporting it some means, it is a small one we can machine it heavy machine it is possible, but it is always preferred that we machine it with putting into 2 centers. It on side it might be dog tail and other side the tool post or else this is one side is fixed to the chuck other side is a tool post. And tool post is holding this shaft while machining for that we need center hole. The special tools are there by which we can make a center hole. Even we can make this piece machine in may be in some other very rough cutting machines say 2 25 millimeter long with center or maybe 222 or 23 with this center hole we can take this piece and then we can put another lathe for final machining.

Now, while will machine that then a designer may be tempted to give the dimension here because he need the lens for gear fixing say it is about 68 millimeter we have this 68 millimeter. So, we need 60 millimeter here this spacer is 15 millimeters. So, 15 millimeter here bearing is 18 millimeter 18 millimeter here. So, we can put the dimension like this, but in that case while the machining will be done the operator the machine man he has to add this thing to calculate the dimensions and then we will do.

So, a good designer a good say little drawing particularly, if it is a precision industry or if it is a air cap industry or so, you will find that in that case, there are designer he is making a drawing and then the manufacturing engineer he is making a that he is modifying that drawing before give it handing over it to the machine man.

But in that way, if you see what are the important dimensions here? First of all 220 that you have to keep in mind, then first we will consider that here the bearing will sit for which the width if you can remember that 18 millimeter width. And after that we will make this lock nut and lock nut thickness is from the catalog it can be changed it is only 78 millimeter ok.

So, maybe totally if you give including the washer it will be 10 millimeter maximum of this size shaft. So, maybe keeping at 14 or even 12 millimeter will be ok, but that washer it should touch the bearing keeping that this portion should be less than the bearing width. So, what we have done we have taken 30 millimeter from here to here and for thread we have kept 14 millimeter. So, that this space is 16 millimeter and we are sure that we will touch into the bearing ok. So, that is done.

Next, we have to think of that it will be for the spacer we will put the spacer. So, what we will do we will take, we have major and keeping this space for gearing a less it is already calculated design engineer he has calculated and he has put this dimension 52 of 42 diameter. And then this space for putting the gear and there as you find the diameter is width tolerance here we have put the tolerance, we have taken 43 millimeter k 5 for k 5 plus minus value are there this can be done.

And in dimensioning there are 2 ways 1 is that you simply put that number, because that chart is available manufacturing engineering he can dictate or the even in machine when he knows what are the tolerance will be there and alternatively you can put the plus minus value there itself depending on the plus minus value and the surface finish what we have mentioned here. Here what we have done we have used 3 triangle 0.8 this means that this should be super finished.

But, not necessarily ground for grinding this value 0.8 here which you have given that is called RMS value of surface roughness. Either you can put in this way alternatively there is another way that you can put something like this and 0.8 everywhere.

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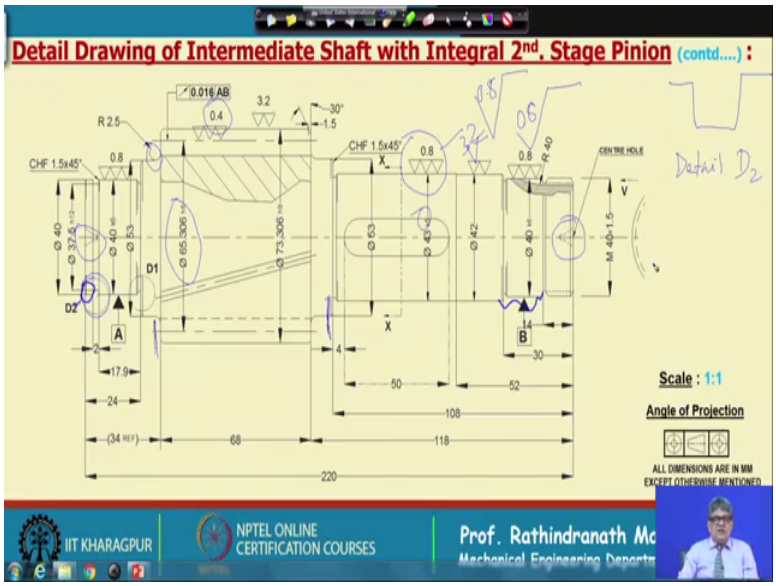

For example, here also thus where the bearing is climbing 0.8 here nothing is coming. So, double dot means it is 3.2 as you see here. So, it is just fine cut, but it is not the superfine cut. Usually for this you may need for grinding this tolerance, but it is also possible with a good finish cut by the by lathe ok.

So, next that here now probably while the machining will be done the machine man what he will do he will look into this diameter, here it is 53 and here it is 43 and here it is 42. So, probably he will cut this portion 108 or a little less of diameter very close to 43 plus he will cut this one and then he will gradually finish this and he will reach here.

Then, he has to look in the other side. Similarly other side he will cut up to this point the dimensions are given in that way. And as you find here there will be a circlip groove for circlip if you remember we have used the circlip there. So, there will be groove for circlip and that dimensions are separately mentioned somewhere say here we have given the D 2 1 circle and we have written D 2.

Somewhere we will make the detail D 2 and where as specified by the circlip group manufacturer you have to put the groove accordingly, but one thing you should notice that this end from this end where the bearing will sit that should be less than actual bearing width and some tolerances are there we have taken 17.9 whereas, the bearing width is 18 and these grooves are made in such a way that this just it will go inside and really it will be somewhat tight fit.

But, it is not that dimensions should be such that that circlip should go inside otherwise there will be a problem. And after the circlip this length is usually 3 4 millimeter for this shaft size we can keep very little more there. So, these are about the dimension of the shafts and as you find here, we have mentioned the pitch circle diameter, but sometimes it is not given here because the gear data will be by the side of that and on the pitch circle we have put 3 triangle with 0.4.

And that means, the surface finish of the gear teeth will be of 0.4 micron, usually it will it will demand the grinding, but that is just to show this dimension this gear box what we have designed we need not go for grinding a good hobbying will do? But, if you ah; that means, this perhaps we can put a little more 0.6.7 micron surface finish will do.

And, here as you see this corner radius we have mentioned the corner radius another important dimension if you look into that this is that here we have put with a triangle field in triangle A and here we have put b and here we have written a an arrow inclined arrow then 0.16 and A B this means that if you consider the cylindricity of A and B and here the pitch circle, that may not be all the axis may not be perfectly matching.

They, may be slightly unclined inclined, because when we will cut the gear then this will be put into other machine, gear cutting machines, hobbying machines, there we have to center, it again we have to cut, it and maybe slightly that table itself have sign slight misalignment also while we had machining this shaft these 2 end maybe shifted slightly this way and that way.

Here, this means that whatever that say they are making some angle and other things; that means, if we consider this center with respect to this center making a circle some eccentricity that eccentricity value it is maybe point not 1 6 millimeter it is like that. So, for that there is more detail result with the manufacturers I have just this idea and I am giving this idea to you sometimes instead of inclined this one or along with that there is 2 circles 1 dot 1 center and 1 circle is drawn and then also some value is there; that means, that means what might be the eccentricity between these 2 center just to maintain the cylindricity of this gears.

And, here as you find that this is a fine thread we have M 40 into 1.5 and these details also this group details are not shown here, that is also made separately detailed D 1 these are usually a tool is available that tool, we can put in there and we can cut it. And as you

find the tolerances are given that to remain sense, but by no means all dimensions we have given here this is just an sample drawing.

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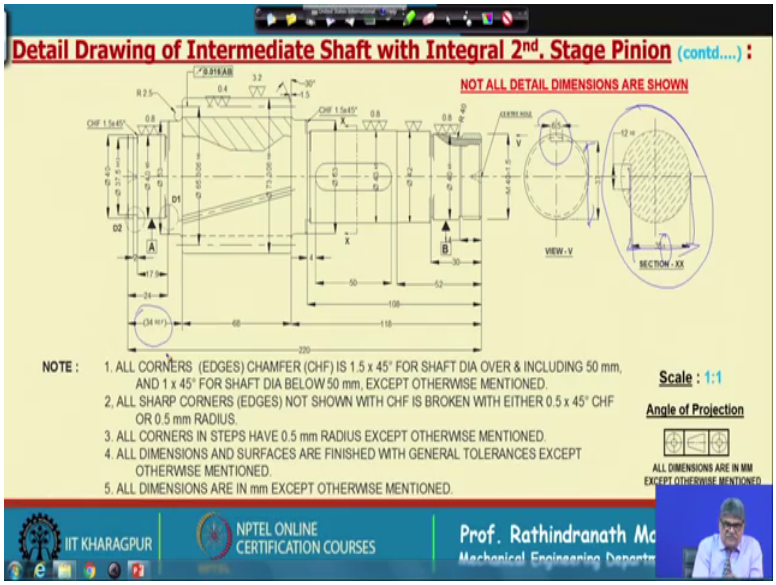

Now here this if you look into this we have with this drawing there are notes, then first note is that all corners edges which has chamfer. Chamfer means this corner are cut is 1.5 into 45 degree for shaft dia over an including 50 millimeter and it is 1 into 45 degree for shaft dia below 50 millimeter.

So, if it is not mentioned we can give it give that is chamfer. Usually each manufacturer having their own data for that one code is there. So, instead of giving that they put simply the poor there with an arrow with an pointer there these are given ok.

So, one can know that what it is you can finish. So, you can read this note while if this note will be available with you can read these what are given. This is only few example maybe some additive notes are there, as well as there will be note for heat treatment etcetera.

Now interestingly if you look into the key ways here the key way it is shown, while I was calculating Q A there it is a specified what will be the depth of cut on the shaft, but depth of cut on the shaft you cannot measure on the machining, while you are machining, if it is the same see machines or somewhat, if there is measuring good measuring device you can measure during the cutting process.

But, ultimately you have to measure these dimensions this is nothing, but the depth of cut mentioned there that minus subtracting from the diameter there. And; obviously, there will be tolerance also some tolerances of course, yeah a on the shaft you have to give some tolerances. That you have to calculate or you have to consider from the specification and that you have to give.

Similarly, for this locking groove that is also cut in this way this mention of of course, for locking groove you need not give the tolerances, whatever the locking in that no sigh 8 80 j you can say that 1 A on projected portion that dimensions is given you can make slightly more than that. For that also some special cutter is available or U j side and face cutter here with that you can make this groove say 6.5 probably that thickness was 6. So, we have given 6.5 and here it could be 37.5 if you look into that in here that there it is given 37.5 from the bottom true the washer not and we have put here 37 millimeter.

So, this is a brief idea about how to make the detail drawing? We have to be very very careful and to know dimensions should be repeated, in case you have to repeat just for the confirmations, then you can put say for example, 34 millimeter here. You can see this is this plus this plus this is 34 millimeter and that we have put as a reference for measuring purpose ok. So, that you have 2 mentions.

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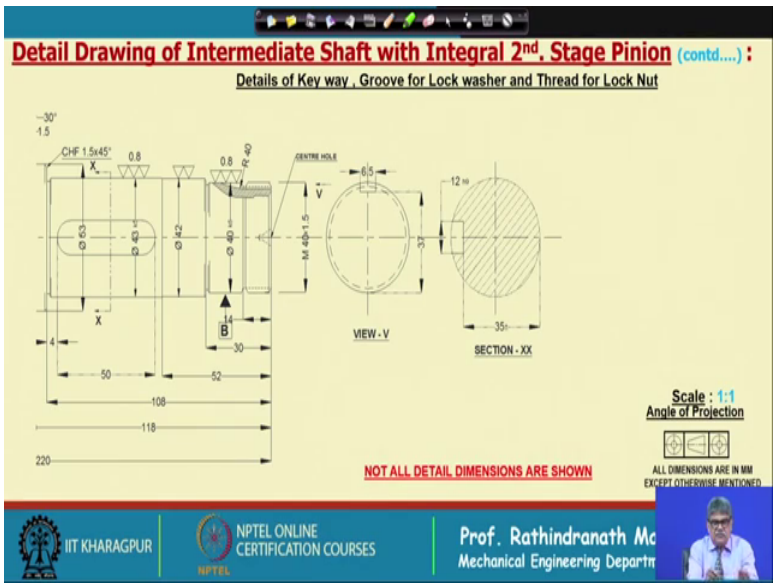

So, I have shown here this right hand side of this for the keyway and other things, but that already we have explained.

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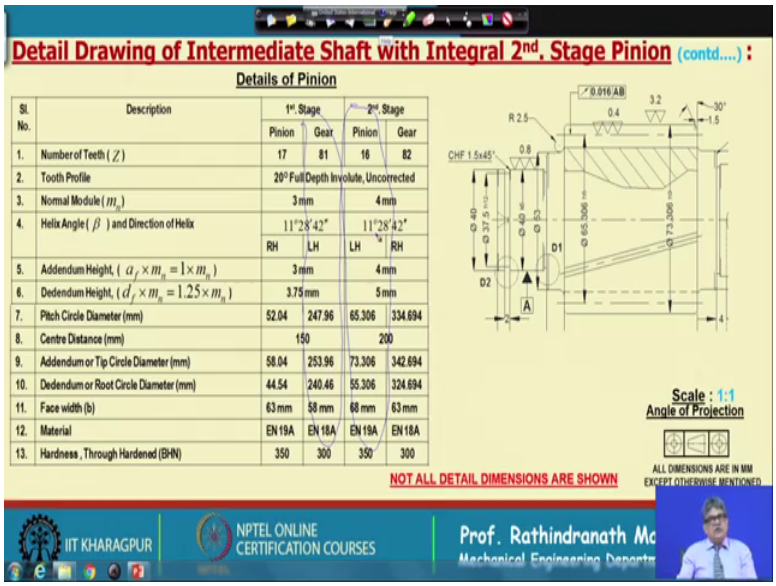

And, then this is the left hand side of the pinion part it is given and here this gear data is shown. Usually only the gear data for these this pinion will do. So, in that way I I suggest that you have to better to give that that first is gear dimensions along with this pinion dimensions here with this drawing. These will easily, if there is some mistake or something one can easily understand only this pinion dimension will do, but one can provide these 2 dimensions.

No harm if you provide this full chart there for such a small gear box, but this has to be provided with destroying along with the notes on heat treatment and other requirements.

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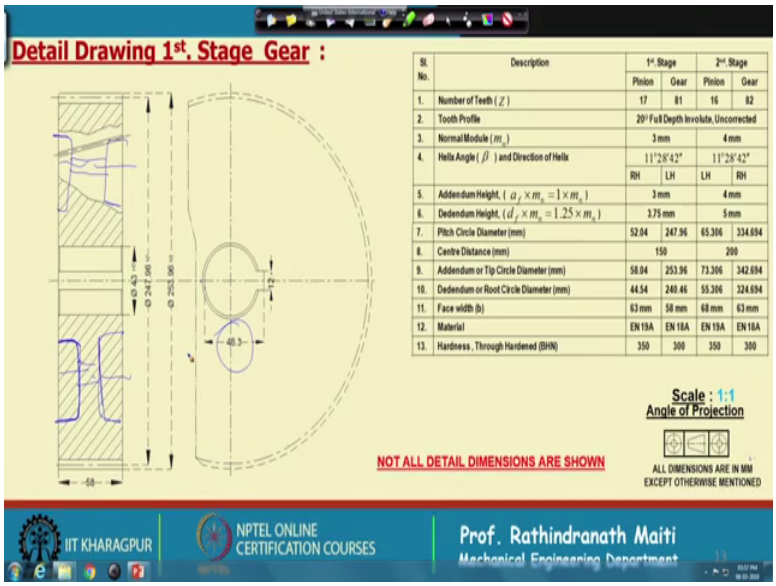

Similarly, we can develop the drawing detail drawing of the gears here I have not shown much dimensions, because only important dimensions are the inside diameter, outside diameter and thickness. Then this corner finished the chamfer everything that can be followed from the general rule.

However, one important thing is there even if such small gear sometimes, some materials are removed from here. If it is a if the if is made in large quantity then from both side this materials are removed and also you may find there are holes.

See, this is a ring sort of things and there are holes maybe 4 holes. That helps in mounting the gear while you are machining ok. And of course, the material will be less suppose, if you go for forging you can rough forging can be done with that and then machine finish can be done on that.

And importantly for this key groove here it will be made by slotting; that means, it will be through from this side to this side and we have to mention from the bottom to the top of this, but this we may not need tolerances because there will be some clearances. So, whatever the depth of cut is suggested say T 2 on the chart, if you look into the key table and then add that one with the shaft diameter and put that value here it is and this width is 12 that is of course, needs some tolerances ok.

Also the gear data we have provided here and this is the end of detail drawing thank you and I would like to mention here that detailed, while you are making detail drawing each and every component you have make a detail drawing ok. So, I have shown only the sample of the one shaft with integral pinion I think following that you can develop also the detail drawing of input gear and following the first is gear drawing, you can easily developed in the second stage gear then of course, housing you have to each and every point you have to consider and then while making the detail drawing of that you have to make on the shaft what you have done of course, one thing is there that we are locking the bearing only at one side. So, other side is free.

So, while we are thinking of the width it is not that important. So, bearing may be slightly inside the box or inside the bearing mounting it may not affect much will not affect much for such thing ok.

Thank you.