Gear and Gear Unit Design: Theory and Practice
Prof. Rathindranath Maiti
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 21
Development (Layout) of Input Shaft and Integral Pinion

Welcome to gear and gear unit design course. This is module five that is, this means that these lectures are for week 5. This is design of general purpose, industrial helical gear, reduction unit part 3, in last lecture of last week. I have already described how the intermediate shaft is developed. So, in this lecture , I shall cover development of which is layout of input shaft and integral pinion and outline of the lecture is that design problem, gear data dimensions first layout recapitulation, then development drawing of input pinion integral with shaft.

That is the main topic bearing dimensions, for initial choice of bearing then development of pinion end side shaft and bearing placement then pinion end bearing locking arrangement use of circlip. Then development of input side shaft and bearing placement and step of input side shaft, for oil seal then development of input end of shaft and finally, probable bearing locking arrangement with housing. We are not developing the housing.

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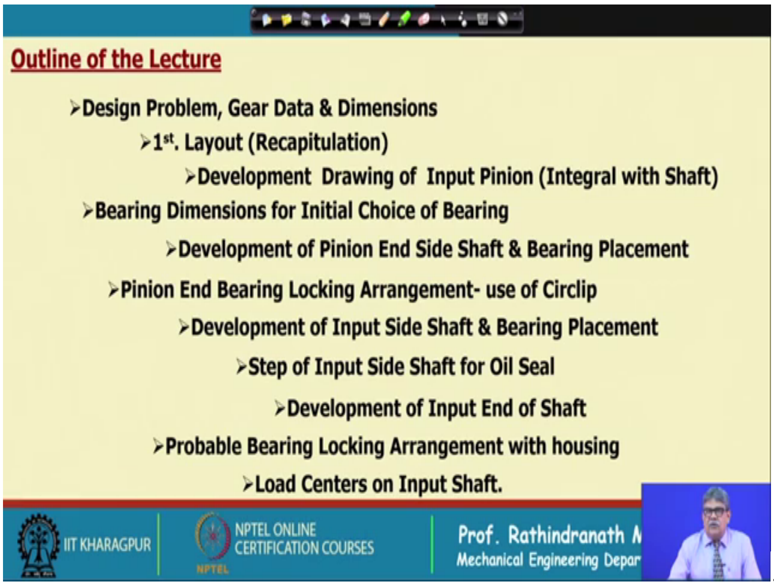

Now, but we will think of how it can be locked. It is essential and next load centres of input shafts also will be shown, because with this little drawing, it may slightly change, what we already assumed earlier.

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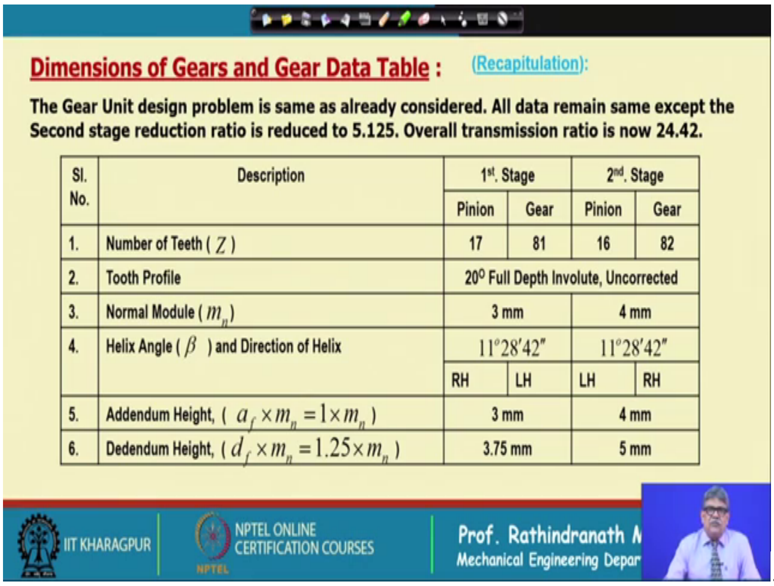

Now, dimension of gear and the gear data table that is, already we have seen. So, it is again shown here, we shall keep in mind that basically, when we started this problem, then to cover a reduction of about 40 in two stage, we choose hostage, a very low around 3 sorry, around 4.0 something and second stage, a little higher that is just to cover in two stage, but later for normally, for two stage, a reduction ratio of total maybe 15 to 30.

He is very good, ultimately keeping inputs shaft and intermediate shaft same. We have chosen another ratio for which total ratio comes 24.42 and in the second stage, the ratio is 5.125, already we have developed by integrals shaft.

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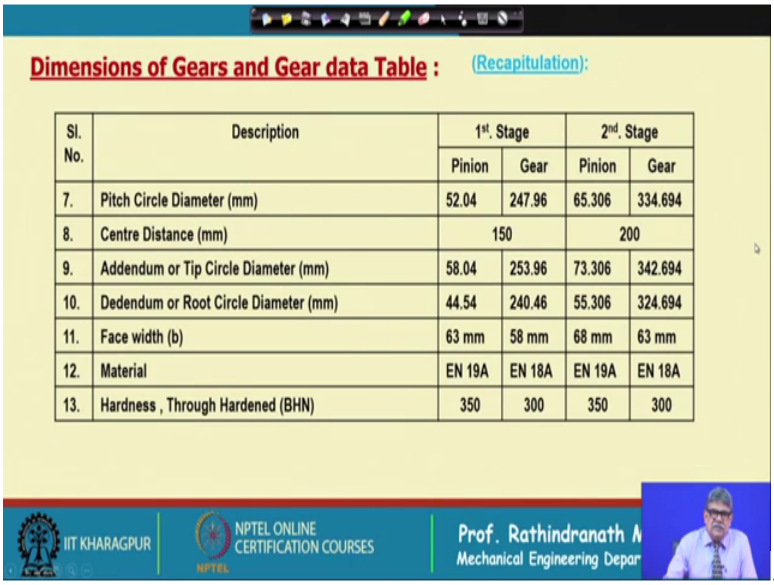

Sl. No.	Description	1st. Stage		2nd. Stage	
		Pinion	Gear	Pinion	Gear
7.	Pitch Circle Diameter (mm)	52.04	247.96	65.306	334.694
8.	Centre Distance (mm)	150		200	
9.	Addendum or Tip Circle Diameter (mm)	58.04	253.96	73.306	342.694
10.	Dedendum or Root Circle Diameter (mm)	44.54	240.46	55.306	324.694
11.	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

Now, this is the gear data, is still continuing the pitch circle diameters centre distance and other dimensions are given here, also material is mentioned and then finally, we will start drawing.

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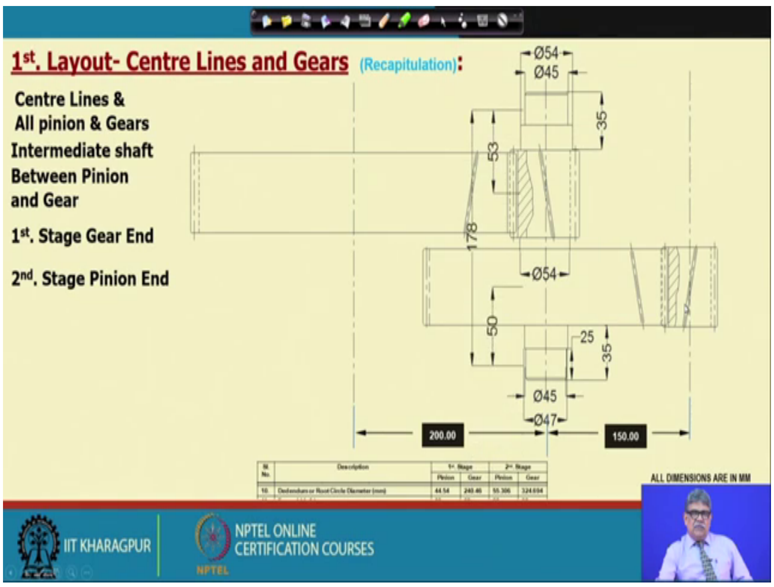

Now, before that the first layout centre lines and the gears that already we have, which we have developed, that is also shown here.

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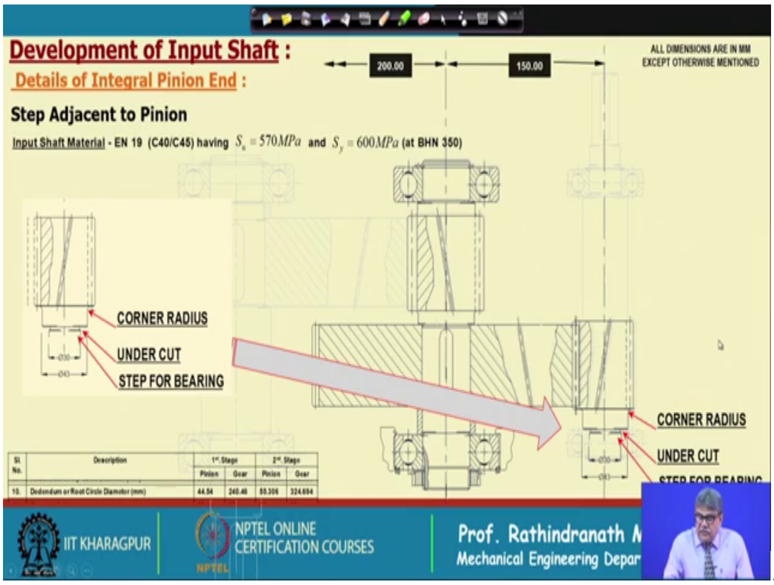

Say we developed this much earlier and next, we are, developing the input side of this shaft. Now, this is the material, is shown as well as that, what is the denim circle, that is also shown and it is shown the input portion of the pinion and then there is a step and then the, we are, we are gradually, we shall develop the, seat for the bearing, this is, this is the pinion end, other side will be the input end.

Now, from the room diameter of the what the room diameter of the pinion, it is given 44.5 for input shaft. So, therefore, we have taken. These have dimension and just that adjacent to that, it is slightly less than, it is with maybe even 44, may be taken, but we have taken here perhaps 43 around 43 and then the, here the, as you see the corner radius is, has been provided and after that, we have reduced this diameter to 30. This means that, we are going to select a ball bearing of 30 millimetres here.

I would like to mention that in intermediate shaft, the bearing here, we have taken bearing, same bearing for both sides, which is 6309 means inside diameter 45 millimetre, but there we found that the bearing is, have life near the double. So, here we initially, we can make the shaft either 35 or 30, because still we can compromise with 6308, bearing for the intermediate shaft, if necessary will change later.

But here 30, they choosing a bearing of 30 inside diameter, probably will be and in this stage I have shown that there is a corner radius, which we have taken then we have kept some length and after that what we find there is under cut; This under cut assuming that the diameter for bearing seat that will be ground. So, this under cut is better to have better grinding up, to the last point of bearing seat and the grinding wheel would not touch the step. So, this, this already we have discussed and then this is the developed figure here.

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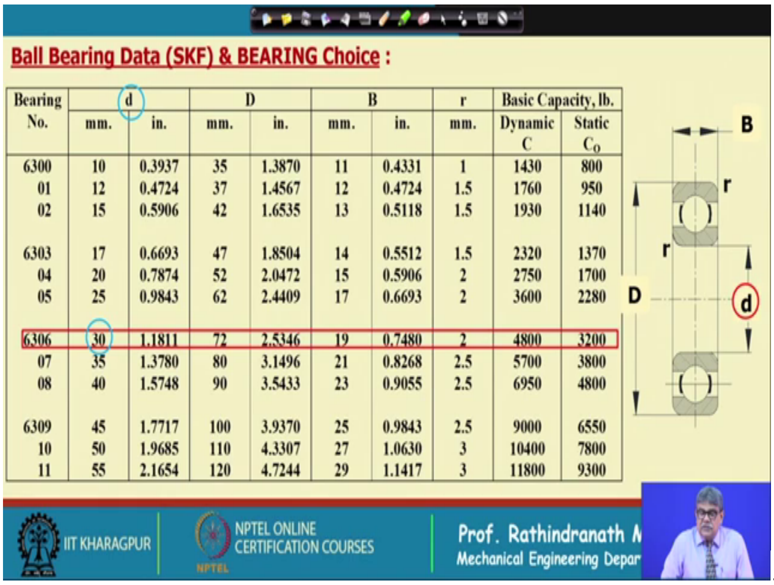

Bearing No.	d		D		B		r	Basic Capacity, lb.	
	mm.	in.	mm.	in.	mm.	in.	mm.	Dynamic C	Static C_0
6300	10	0.3937	35	1.3870	11	0.4331	1	1430	800
01	12	0.4724	37	1.4567	12	0.4724	1.5	1760	950
02	15	0.5906	42	1.6535	13	0.5118	1.5	1930	1140
6303	17	0.6693	47	1.8504	14	0.5512	1.5	2320	1370
04	20	0.7874	52	2.0472	15	0.5906	2	2750	1700
05	25	0.9843	62	2.4409	17	0.6693	2	3600	2280
6306	30	1.1811	72	2.5346	19	0.7480	2	4800	3200
07	35	1.3780	80	3.1496	21	0.8268	2.5	5700	3800
08	40	1.5748	90	3.5433	23	0.9055	2.5	6950	4800
6309	45	1.7717	100	3.9370	25	0.9843	2.5	9000	6550
10	50	1.9685	110	4.3307	27	1.0630	3	10400	7800
11	55	2.1654	120	4.7244	29	1.1417	3	11800	9300

And the next, we shall choose the bearing and diameter is already 30 and this diameter is 30 and what we find 6306 bearing can be selected the from the ball bearing groove. The static load capacity is 3200 pound of course; it is given in the pound, this bearing. I have chosen that is escape bearing and dynamic load capacity 4800 in pound.

If we divide by 2.2, it will be around 2200 or something like that, that will be Newton 2200 will be the dynamic capacity and later we will check, whether this bearing, what we have selected at this stage, that is suitable or not, but first of all we have to make the layout. So, that we can place the bearing and we can find the load centres.

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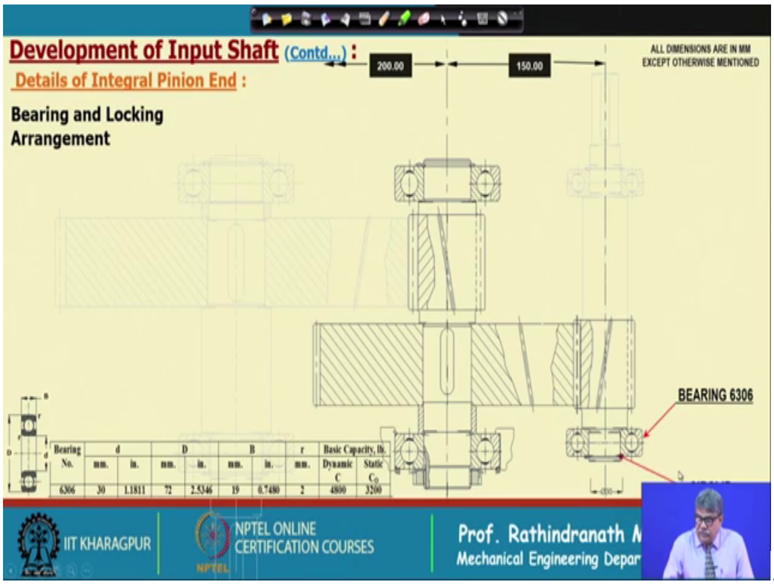

Now, bearing and it is locking arrangement. So, bearing selected already we, I have shown, but here it is also displayed, what is the capacity of the bearing and size and then we place the bearing ok, and that bearing is locked with a circlip and we.

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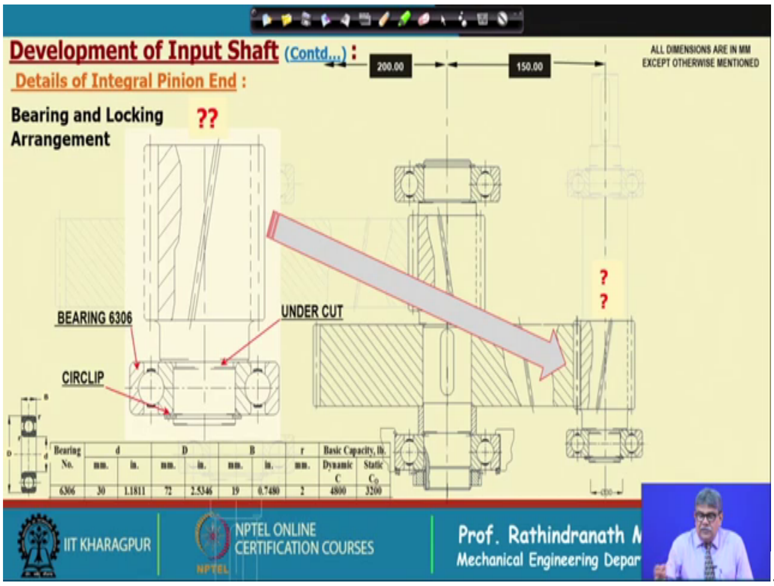

If we look into the developed figure of that, there is the , this portion I have shown in the developed form and this is the bearing and this is the circlip and one mistake is there in the pinion and the intermediate gear. There is two centre lines, but there will be only one centre lines. This is due to the adjusting the drawing, this error is there, but you consider there is only one centre line this, just at the end of big arrow here itself.

Now, we can proceed to next step , the undercut is shown I have explained this is under cut, usually there will be a specific tool, which can be used to give such undercut depth is around 1.5 millimetre or so, and width is around 2 millimetre. We shall discuss more about this under cut, when we will make the detail drawing of the shaft. Now, next what to do? We have to now, develop the other side of the input shaft other side of the pinion input shaft ok. So, next, we consider that as this root diameter is 44.0; something. So, here also we can take the dimension around 43 and add the shaft, where the bearing is sitting diameter is 30.

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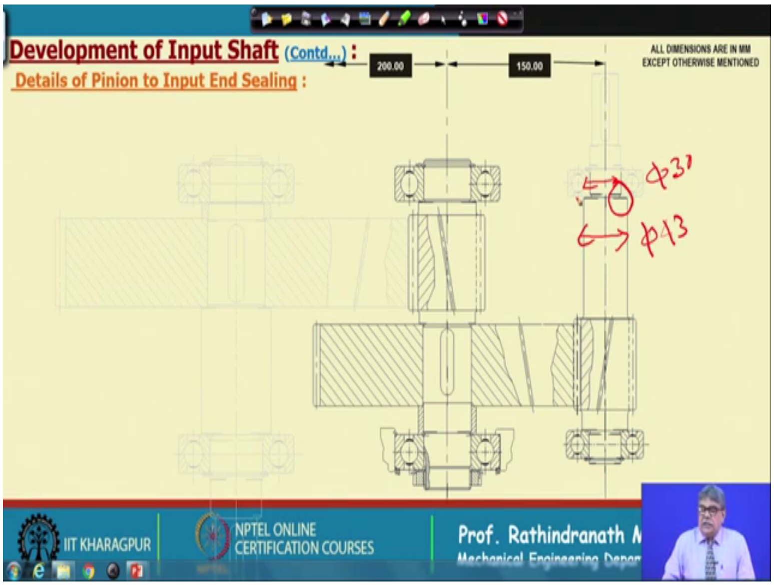

So, we need not put any other special or anything the bearing, inner race can directly rest on this solder of the step here, it can stave. So, rightly this is around 43 and here it is around 30. So, this means that we will have 13 millimetre. So, 13 half of that 6.5 millimeter is good enough for taking load through, in a race of the bearing now.

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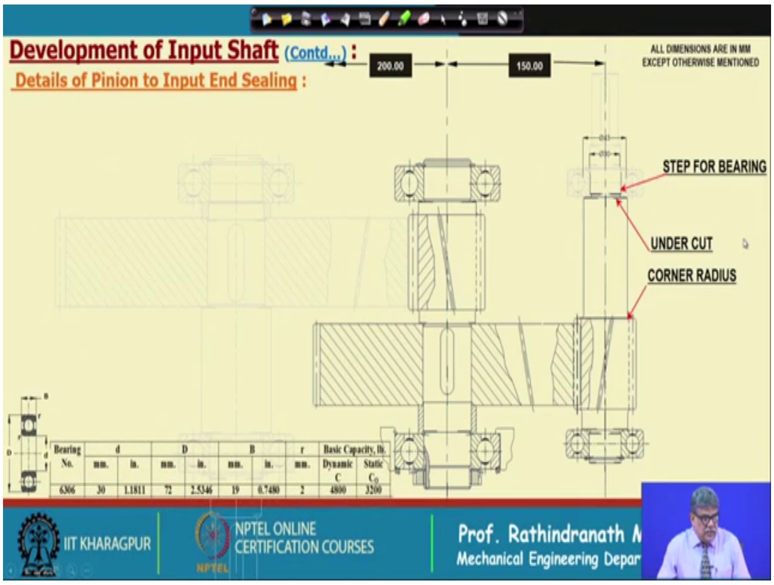

So, again we have the corner radius here, as shown. This is the corner radius that corner radius is given due to this corner radius and edge. This diameter is very close, you an impression of gear cutting may be evident, maybe it will be prominent on that corner also, but it does not matter it will make no harm of the shaft.

Now, this is the step for bearing and this is the undercut for the bearing other side also and this is again 30 millimetre and the step of portion is of 43 millimetre there, what I will already have described and this is the bearing, what we are using.

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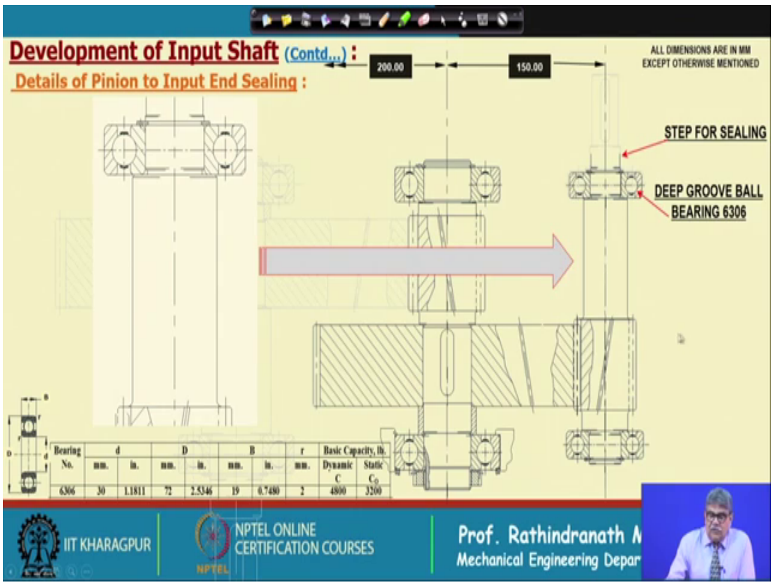

So, we will now, put the bearing. This bearing is now, put after the bearing, what we have done, we have used in the circlip for locking, but as well as we have also shown, the stiff for sealing, we have to put a sealing element, because this shaft is the input portion of the shaft, will be out. It will be exposed to the atmosphere.

So, there we must have sealing arrangement. We shall discuss later, on this matter, on this issue. Now, this is the developed figure of that portion, what we have developed more clearly here, what we find that is, this is an under cut is provided for the bearing and as well as there is also the circlip.

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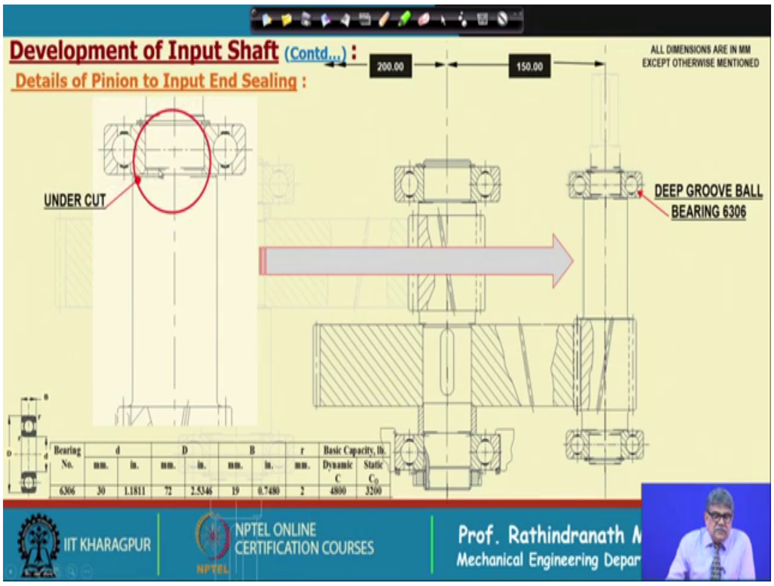

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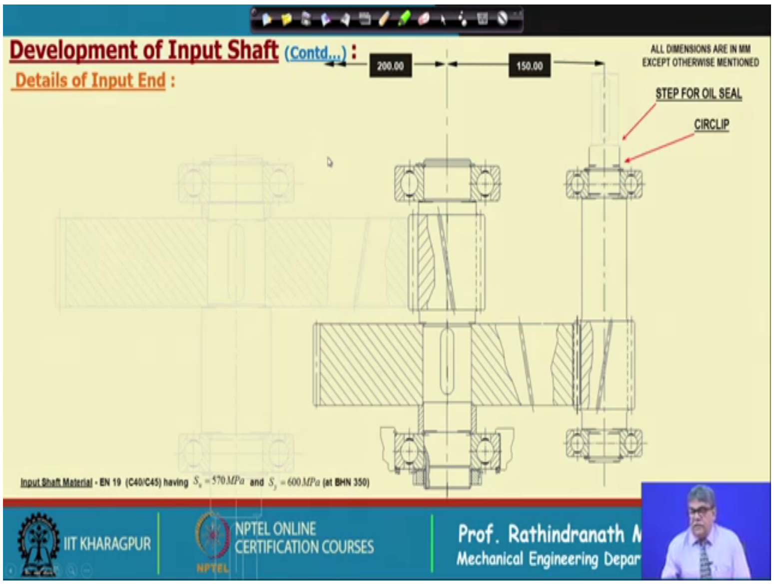

Now, next stage, we major that this for stiff for oil sealing. We are keeping around 12.5 millimetre have about half an inch and usually this while, since our seal of 30 diameter will have an thickness of 8 millimetre or; so, assuming that and after that there will be space for the cover material, we have made it like this and then the shaft diameter is further reduced for input; that means, a coupling to be fixed.

There usually that portion is kept long, perhaps I have not mentioned for anything. Do we mount it on shaft? What should be the hub length? Usually hub length is 1.5 to 1.8 times, but sometimes it is kept also two times and then only single k can be used, if it is very less, but in any case it should not be less than 1 diameter of this shaft.

Because then it will be problem in two ways, one that key, one single key may not be sufficient and second is that the, thickness. It may be that disk whatever would you be put on that, that may, may slightly inclined, not perpendicular to the axis; however, it is done, even it is less than shaft diameter, if we go for the other type of key methods, what is that like gear type coupling and others and here this shaft diameter, we must have a key way.

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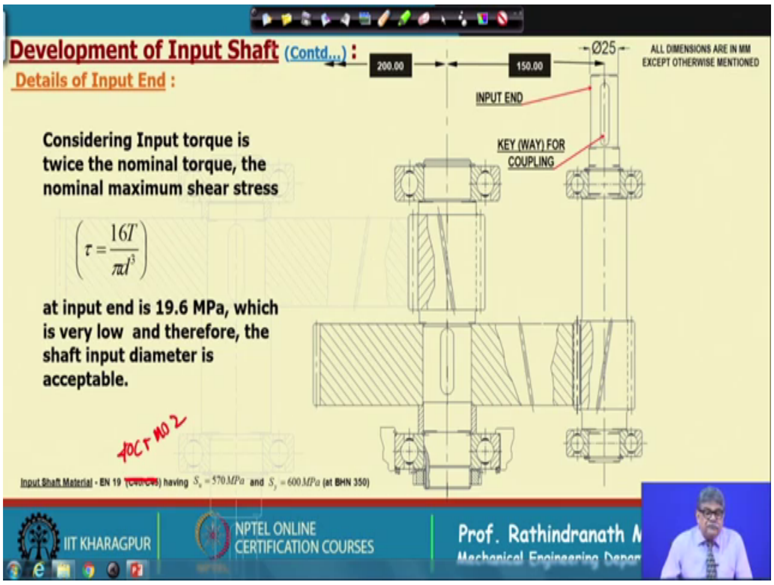

And this diameter we have taken as, already mentioned, 25 and here as, as this length has been kept sufficiently long in comparison to, the shaft diameter, then probably single key can be used. There are dice key dimensions; it is standard key dimensions that are available. So, we can use that.

Now, while we are selecting, such diameter, we should initially at this stage, we can verify, whether this is sufficiently strong, just if you look into this, the torque is torque, input is, will be there and there will be coupling. Coupling means there will be no axial load. Normally, there will be no axial load and later of course, we can change the design in such a way that, which can take also a little bit axial load or this shaft diameter, what we have already taken, that may take the axial load also ok, but first we can check with this, what will be the shear stress at the considered talk.

Now, considering two input torque is twice the nominal torque, what we have already considered for gear design, the nominal maximum shear stress can be derived using this formula, tau is equal to shear stress tau is equal to 16 times torque divided by pi into diameter to the power cube, at input end is, it is all we have calculated, it is 19.6 mega Pascal, which is very low and therefore, this have to input diameter is acceptable here, it can be, we can conclude that we do not have to change this shaft diameter, even if there is some axial load is coming later, we will check that.

Now, input shaft material as already told it is here 19 and sorry, there is a mistake that it will not be C 40 C 45, it is not very equivalent, it is something else. So, this is a mistake, obvious mistake and here it will be, it is as far, I remembered 40 C r 1 M o 2 that is 40 means carbon percentage will be 0.4 percent and we can of course, right here. This will be apparently 40 C r M o 2; that is chromium will be 1 percent; monomer will be 2 percent.

Anyway this can be confirmed later with the assignment, this will be another note. It will be corrected; however, it is having ultimate strength 570 mega Pascal and the yield strength is 600 mega Pascal and what the shear stress, we found is very-very less in comparison that.

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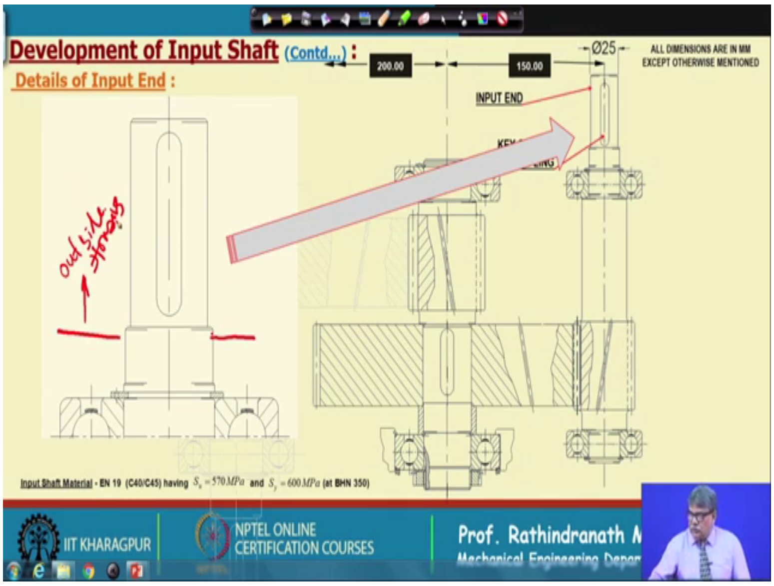

So, this is again the developed portion is shown here, you can see this how this hardly be spoke to the lock that, that one and this is for the sealing portion and this is for the input coupling, input coupling. This portion from this portion to this portion and maybe a little percent of this, if we consider the housing, housing cover will go through here, something like this. So, this is outside the housing.

So this is the input side now after that. So, all the full shaft, input shaft is already developed and then, we will look into back, this is, this is called sub assembly of inputs shaft whereas, this is the sub assembly of the output shaft; So, locking with housing.

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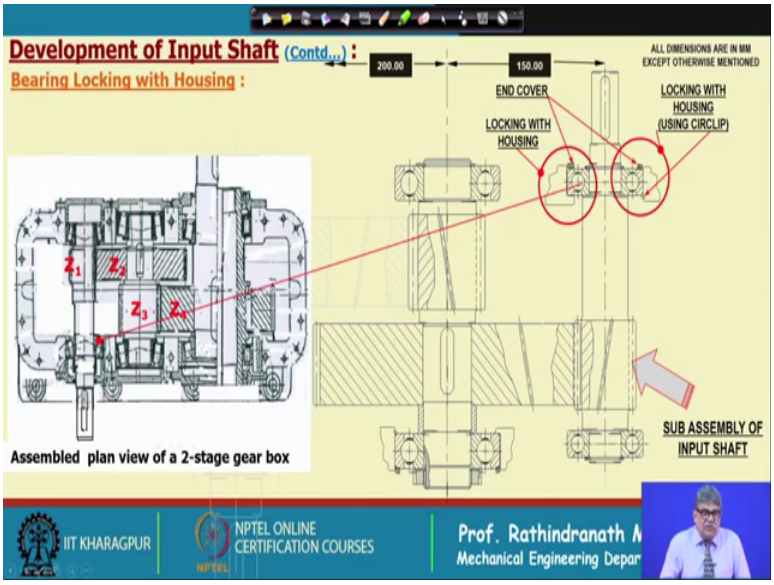

Now, we will think of the locking with housing. Now, here as you see, has already described. We can use is circlip for locking the inner end of the bearing, if we, why we are trying to lock this, this end bearing, because as the pinion is closed to other end bearing, that will have the maximum load radial, loads here, the radial loads will be less. So, what we can do? We can lock this bearing fully.

So, that it can take the axial load irrespective of the direction of rotations. So, that we are doing on the other hand. This bearing will remain free and if there is any expansion of contraction of the shaft that would be, that the, the other end bearing will shift axially, a little bit and that is allowed.

Now, this locking with the housing, it can be made like this, that for this side bearing , for this side bearing, the housing bore is made straight and we use is a circlip there. You use a circlip there and other side, the bearing over, which is something like this, along with this small percent that will come there and that is fixed by the bolt. So, the bearing cannot move actually, neither on the shaft nor on the housing. If necessary there is, seam is used to adjust the space cover with housing and the bearing end ok so, that we will again discuss, when we make the little drawing.

So, we have used this circlip here; however, it, this is the end cover, already discussed; however, it also can be locked like this white, while we are boring, instead of making this circlip group, rather we keep some material. So, that bearing outer race can rest on that and then cover from the other sides. So, it is in cover that is shown here and this is, we are that input shaft, we have shown. So, if we consider that as the gear box, then we have completed that first layout of the input shaft and intermediate shaft is already completed.

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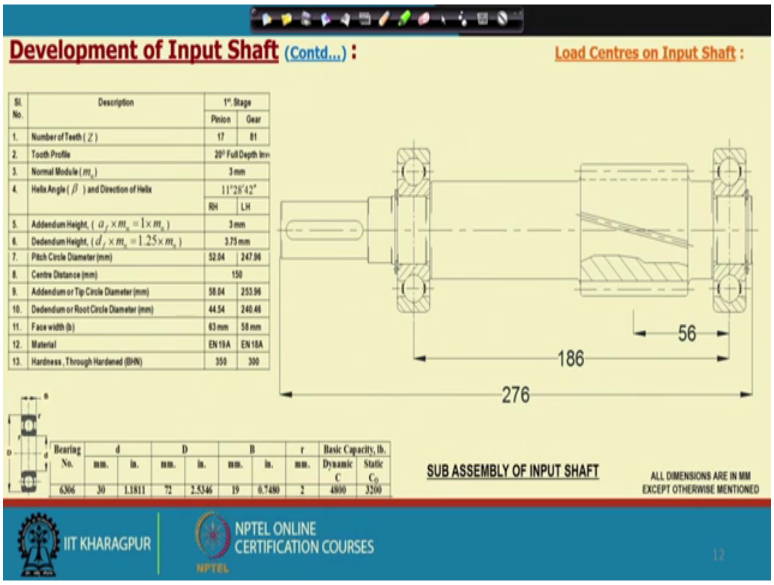

So, now, we can go for the other shaft, but before that; let us say, this is the sub assembly of inputs shaft and if we look into the distance between the two bearings, that is no, this is total length of the around 276 or 275 millimetre. We can, while will make the detail drawing, we can even add just a little bit here and then we find that the bearing distance, the support point of the bearings, the midpoint. In this case as it is a deep groove ball bearing, which is 186 millimetre and the centre of this, the pinion is from is 56 from the mid of the nearest bearing.

So, these dimensions will be required, while we calculate the load on the sax, these two dimension 186 and 56 and now we can proceed for calculating that, what load coming on, on the these two bearings and then we can finalize the shafted design, we can verify that diameter already, we have chosen, that will be satisfactory or not. So, this again, I have given the bearing dimensions, which are the, which we have used and also here I have shown the gear data.

So, if we have these information's, which is drawing another and as we know that how much torque, it is transmitting from there? We can calculate, how much load will come on pinion and how it will be distributed on two bearings and then we will find the bearing life and as well as will verify the shaft design of course, after that we need to also check that the key, what we have selected, whether that is satisfactory or not.

So, thank you; we have completed the layout of the input shaft.