Spur and Helical Gear Cutting
Prof. Asimava Roy Choudhury
Department of Mechanical Engineering
Indian Institute of Technology – Kharagpur

Lecture – 40
Gear Hobbing - VI

Welcome viewers to the last that means the 20th lecture of the course Spur and Helical Gear cutting. So, let us move right on to the subject because we have less time and more topics to cover.

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- . Rotation of cutter provides cutting velocity in
- (a) gear **milling** and gear **hobbing**
- (b) gear **hobbing** and gear **shaping**
- (c) gear **shaping** and not in gear **hobbing**
- (d) none of these

So, as we discussed we will have a quick look at some multiple choice questions. The first one, rotation of cutter provides cutting velocity in gear milling and gear hobbing. This seems to be correct. In gear milling the milling cutter rotates and develops cutting speed, gear hobbing also the gear hob rotates and develops cutting speed. Gear hobbing and gear shaping, rotation of gear shaper cutter definitely takes place but it is for feed it is not for cutting velocity.

Development of cutting velocity in gear shaping is by reciprocation. So, b is not correct, c, gear shaping and not in gear hobbing. So, gear shaping obviously is eliminated already and therefore, c is also not correct. And therefore, we have a to be correct, gear milling and gear hobbing.

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- In gear hobbing, rpm of single start hob of 4 mm module is 100. **Pitch** diameter of gear to be cut is 200 mm. Rpm of gear blank is
- (a) 4 (b) 2 (c) 8 (d) none of these.

In gear hobbing, RPM of single start hob of 4 millimeter module is 100. Pitch diameter of gear to be cut is 200. RPM of the gear blank has to be found out. So, what do we have here starting? Let us write down.

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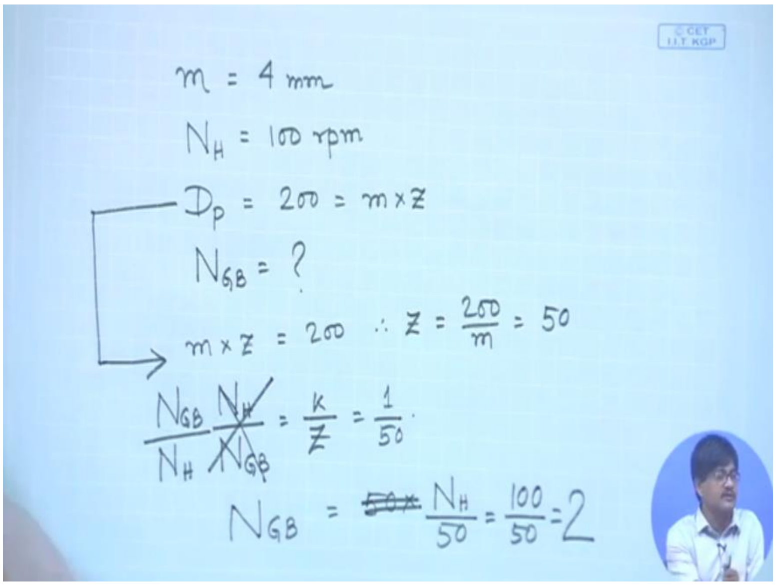

First of all, the rpm of single start hob. So

$$m = 4 \text{ millimetres},$$

$$N_H = 100 \text{ rpm}$$

Pitch diameter of gear to be cut, here nothing has been mentioned. So, we will assume it is a spur gear. Pitch diameter of gear to be cut is 200, so:

$$D_p = 200 = m \times Z.$$

We have to find out rpm of gear blank. This is a statement of the problem. So, once we utilize this particular relation we get:

$$m \times Z = 200$$

$$\therefore Z = \frac{200}{m} = \frac{200}{4} = 50$$

Number of teeth which is being cut is 50. That being so, we can establish our known relation:

$$\frac{N_{GB}}{N_H} = \frac{K}{Z}$$

K = 1, because you will find in the problem, it has been stated single start hob. So,

$$\frac{N_{GB}}{N_H} = \frac{K}{Z} = \frac{1}{50}$$

Once we know that this is 1 by 50, RPM of the gear blank is this one.

And N_H has been given to be 100. So,

$$N_{GB} = \frac{N_H}{50}$$

And K already has been assigned 1. Therefore:

$$N_{GB} = \frac{N_H}{50} = \frac{100}{50} = 2$$

The correct answer is gear blank rotation is 2 rpm. So, let us have a look at the problem. Yes, b is correct, rpm of gear blank is 2.

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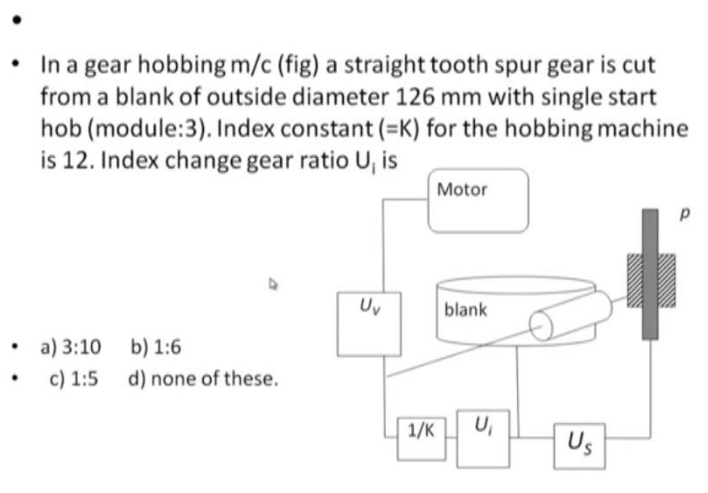

In a gear hobbing machine (figure) a straight tooth spur gear is cut from a blank of outside diameter 126 mm with single start hob module 3. Index constant for the hobbing machine is 12. Now, you might say what is this? Index constant, well, it has been shown clearly in the figure. What sort of gear ratio it is importing into the figure? $\frac{1}{K}$ is the gear ratio; this index constant is bringing in.

And index change gear ratio U_i is therefore, 4 options are given. So, let us work it out. What is the statement of the problem?

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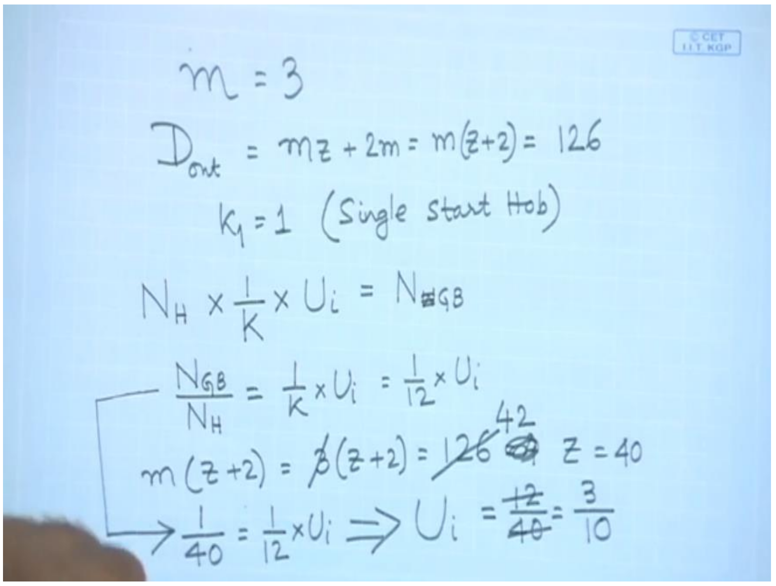

First of all, module = 3. What sort of gear are we cutting? Straight tooth spur gear. So, we have nothing to worry about.

$$D_{out} = mZ + 2m = m(Z + 2) = 126$$

There are 2 K's now. So, let us call this:

$$K_1 = 1 \text{ (single start hob)}$$

Now, what is the statement of the problem? The figure provides us a K value, if we have a quick look at the figure, this one. This ratio is $\frac{1}{K}$ and therefore, it is given that there is a gearbox with $\frac{1}{12}$ here. In that case what should be U_i be? So, let us work it out this way, starting from the hob rotation:

$$N_H \times \frac{1}{K} \times U_i = N_{GB}$$

This is the relation that we have therefore, we can say:

$$\frac{N_{GB}}{N_H} = \frac{1}{K} \times U_i = \frac{1}{12} \times U_i$$

What is $\frac{N_{GB}}{N_H}$ equal to? $\frac{N_{GB}}{N_H}$ must be equal to $\frac{K_1}{Z}$. $K_1 = 1$ and number of teeth which is being cut can be solved from here, m × (Z + 2).

So,

$$m \times (Z + 2) = 3 \times (Z + 2) = 126$$

$$Z + 2 = 42$$

$$Z = 40$$

And therefore, we now we come back to this expression and we write. $\frac{N_{GB}}{N_H} = \frac{K}{Z}$. Therefore,

$$\frac{1}{40} = \frac{1}{12} \times U_i => U_i = \frac{12}{40} = \frac{3}{10}$$

So, the answer is U_i should be equal to $\frac{3}{10}$. Let us have a look here. Yes, option a is correct, others are not.

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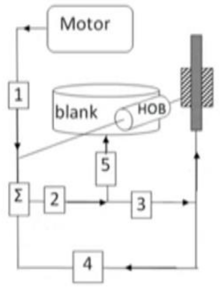

Fig 1

- In a gear hobbing machine the speed gear box has the following location(see fig 1)
- a) 2
- b) 5
- c) 1
- d) 3 e) 4

Next, in a gear hobbing machine, the speed gearbox has the following location. Where is the speed gearbox? Now, this has been hammered into you so many times over several lectures. All of you must be knowing speed gearbox is located here. Therefore, c is the correct answer.

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- To operate a gear hobbing machine at a feed of 0.2 mm/rev the feed gear ratio is found to be 1:25. Feed constant of the machine is 1 (which means all gears, pulleys and other mechanical elements causing speed change are collectively having a speed ratio of 1:1).

Pitch of the feed screw is a) 5mm, b) 6mm, c) 10 mm, d) none of these.

To operate a gear hobbing machine at a feed of 0.2 millimetres, the feed gearbox is found to be 1:25. So, a feed gearbox box value is given. Feed constant of the machine is 1 which means all gears, pulleys and other mechanical elements causing speed change, they are collectively having no effect on the speed. In that case, the pitch of the feed screw is? 5 millimeters, 6 millimeters, 10 millimeters, none of these.

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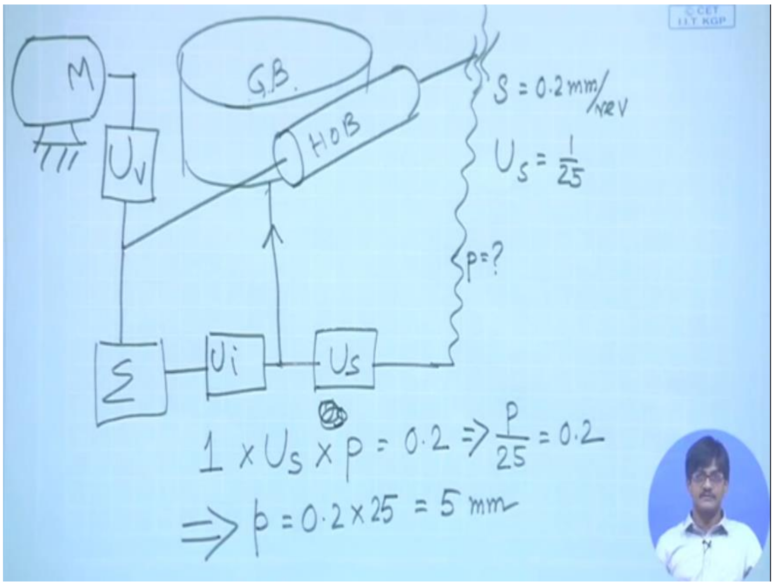

So, let us quickly draw this particular figure. This is the hob. This is the job and the speed is obtained by the position of the U_v here. This is the motor, hob, gear blank. So, tap the power from here, this is our differential. This must be U_i, this is the connection to the work piece and this is our U_s. U_s feeds vertical screw with the help of which the hob comes down.

So, what is given to us let us make a statement of the problem? The statement of the problem is, this feed is given to be 0.2 mm/rev of work piece. What is the feed gearbox ratio equal to?

$$U_s = \frac{1}{25}$$

And therefore, we have to find out the pitch of this lead screw. This is the problem. So, we quickly establish the relation, by the time the gear blank rotates once, this movement should be 0.2.

Therefore, we write the equation this way,

$$1 \times U_s \times p = 0.2$$

$$U_s = \frac{1}{25}$$

$$\therefore \frac{p}{25} = 0.2$$

$$p = 0.2 \times 25 = 5\text{mm}$$

Pitch of the screw must be 5 millimeters. Coming back here, a is the correct answer.

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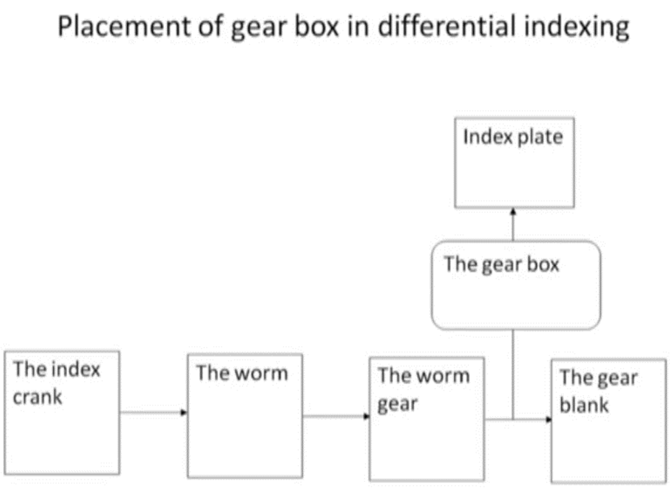

Now, let us quickly discuss the positions of the gearbox in case of milling. Now, that we have become conversant about the positions of the gearboxes in different cases of hobbing and shaping. What do we exactly mean by this? We mean that in hobbing and shaping we had come across different laws or rules with the help of which we were establishing the uniqueness of the positions or locations of the gearboxes in the kinematic structure.

That is U_v has to be at a particular location, U_s has to be at a particular location. Now, once you have gained that experience, I want you people to go back to the case of differential indexing and establish some simple logic with the help of which you can point out the correct location of the gearbox which is used in differential indexing. Let me quickly reintroduce the idea that we had discussed at length.

During those lectures we had an index crank, the crank was rotated. We had a worm which was rotated by this crank. This worm had a relation with the worm gear and that worm gear had on its shaft the gear blank. And here there was a bifurcation of power or gearbox where was placed and it was feeding the index plate which was rotating and ultimately that decided a differential movement to be provided to the worm.

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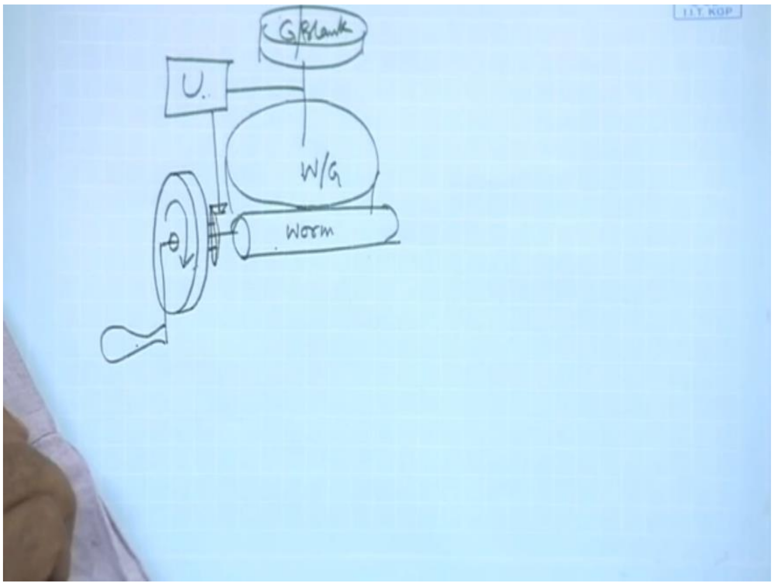

If you allow me to draw the figure, it looks like this. This was the index plate, through this past the crank. This crank went to the worm; this worm was connected to the worm gear. Worm gear had on one side your job. On the other side, it had a gearbox U which ultimately gave its power through bevel gears to this plate. This was what we had index crank, worm, worm gear, gear blank, gearbox and this gearbox was controlling the power to an index plate which was now rotating.

Now, the question is. Why did we decide to place the gearbox here out of all possible places? Now, coming back to the slides, have a look at this that is in this figure we see. This is the index crank, yes, the worm, the worm gear and this is the depiction of the position of the gearbox in this particular schematic view. So, the gear blank from this point we had taken the bifurcation. Now, let us take another possibility.

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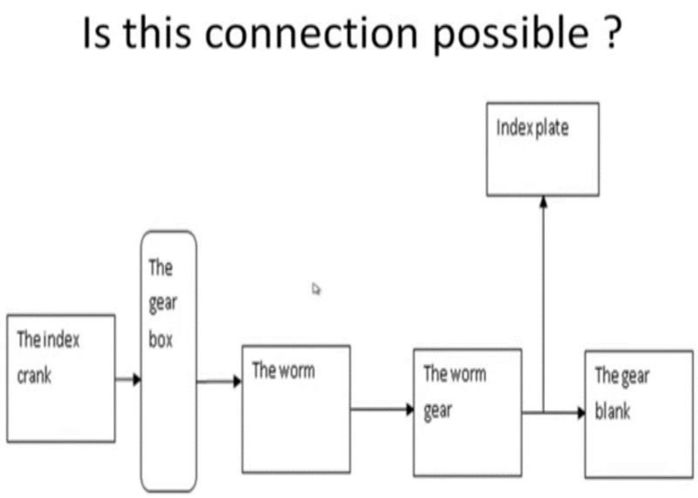

Why not this? So, from the logic that you had learnt about while locating different gearboxes at different places, I would like you to judge, whether the gearbox can be placed just after the index crank. Just after the index crank, you place it just after the index crank so that the worm gets a different rotation, from what it was supposed to get. And the worm gear gets some rotation etc. What problem would it give rise to? So, let us have a discussion on that.

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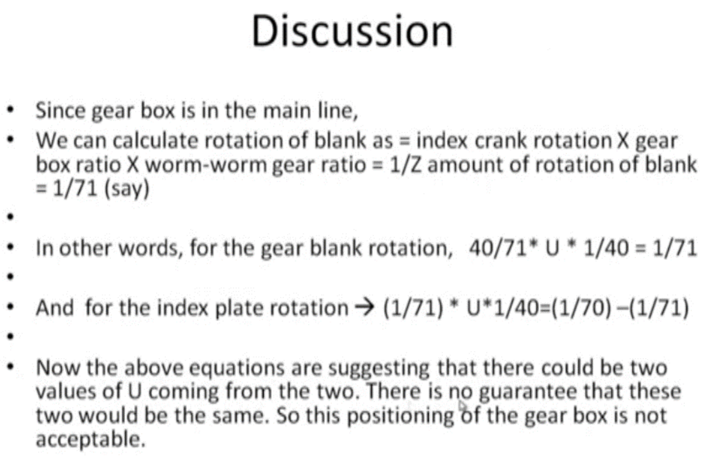

So, we are placing it here. If we place it here, since the gearbox is in the main line, we can calculate rotation of the blank as equal to index crank rotation, so we are going up to the blank. So, it is index crank rotation into gearbox ratio into worm - worm gear ratio equal to $\frac{1}{Z}$th amount of rotation of blank. Now, what does that mean? That means basically let us draw a figure once again. That will help us.

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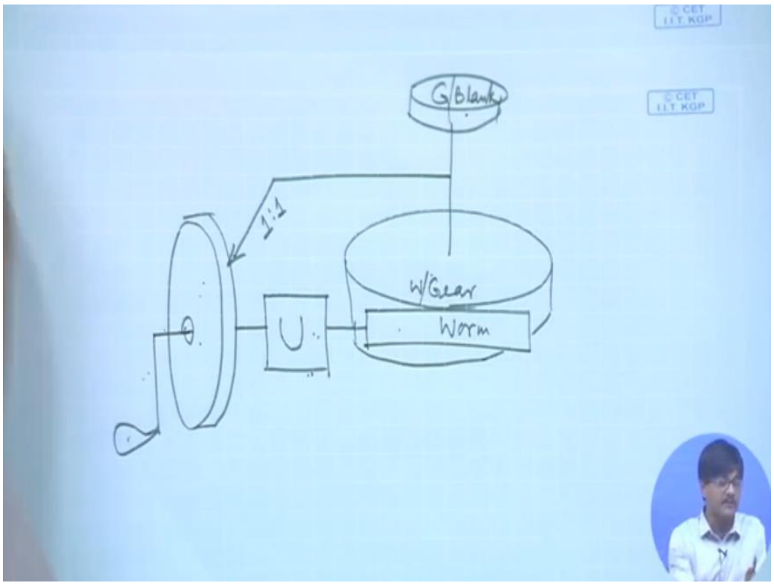

This is our index crank. This is our index plate. This is passing. We are now proposing gearbox here and worm here. Worm gear in contact with the worm. And this is our gear blank and we simply tap this power and 1:1 we give this particular connection. Why not place it here? Are we going to face any problem? Or just because we have studied it in different books it should be placed here.

So, for this one, if you make calculations it will be crank rotations multiplied by gear ratio multiplied by $\frac{1}{40}$ must be equal to gear blank rotation. And, how much is the crank rotation? Since index plate is rotating in such a way that you are getting 1 by say suppose you are getting 71 teeth so, this will be $\frac{40}{71}$. So, coming back to this particular material which is written here, we will say in other words, blank rotation is $\frac{40}{71}$ which is the crank rotation multiplied by the gear ratio, multiplied by the worm and worm ratio must be equal to $\frac{1}{71}$.

$$\frac{40}{71} \times \mathrm{U} \times \frac{1}{40} = \frac{1}{71}$$

Now, if this be so, what do we have after cancelling out?

$$\mathrm{U} = \frac{1}{71} \times \frac{71}{40} \times 40 = 1$$

$$\mathrm{U} = 1$$

From the consideration of gear rotation, what about the index plate rotation? Index plate rotation will be by the time the crank rotates $\frac{1}{71}$. The index plate rotation must be $\frac{1}{70} - \frac{1}{71}$. From this consideration, we will get another value of U. How much will that value be? That value will be equal to $\frac{40}{70}$. So, from here you is coming to be 1 and here it is coming to be $\frac{40}{70}$.

Therefore, this particular solution cannot exist. Because from one condition that is the blank rotation, we are getting U should be equal to 1 and from the index plate rotation, we are getting, U should be equal to $\frac{40}{70}$. So, this location of the gear box is not going to serve the purpose.

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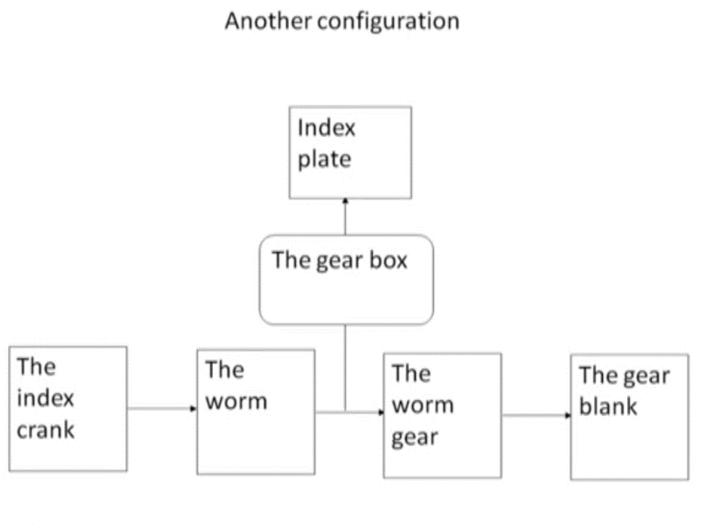

Let us take yet another possible location of the gearbox. What about putting the gearbox here? Ahead of the worm gear after the worm so, if it is after the worm, therefore, worm gets the required amount of rotation and if we do the calculation now. It will be, index crank rotation multiplied by the worm rotation, these 2 are going to be the same and after that, if we have a gearbox that is going to give us the index plate rotation. So, let us write down index crank rotation.

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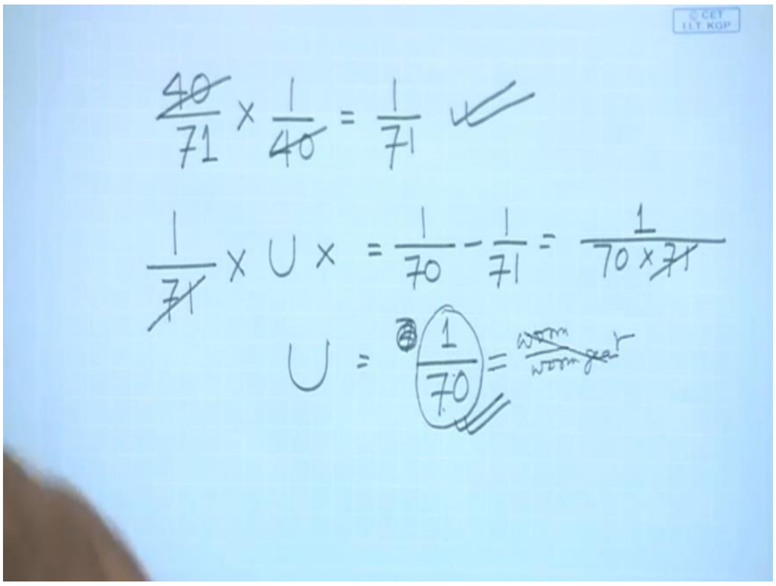

$$\frac{40}{71} \times \frac{1}{40} = \frac{1}{71}$$

That is alright. So, the straight connection this way index crank, worm, worm gear, gear blank. This is working, there is absolutely no problem. What about this one connection? In this one connection if we work this way, by the time the crank is moving by $\frac{1}{71}$.

$$\frac{1}{71} \times \mathrm{U} = \frac{1}{70} - \frac{1}{71} = \frac{1}{70 \times 71}$$

$$\mathrm{U} = \frac{1}{70}$$

So, this is going to work very well. If you put U = $\frac{1}{70}$ but herein lies the problem.

The problem is that while U = $\frac{1}{70}$ looks quite a simple ratio. It is a difficult ratio to obtain. Why? Because this particular ratio is more like the worm and worm gear ratio. And that is why it will be very difficult to be obtained by ordinary spur gears. When you are having a gearbox? What is the point putting a worm and worm gear ratio?

Because, for every different gear teeth that you are cutting, it is going to ask for a different worm and worm gear pair and that is going to be extremely expensive. Therefore, in order to save money, this particular configuration is an obvious rejection. The way this thing has evolved. That is why, this was obviously not one of the preferred configurations.

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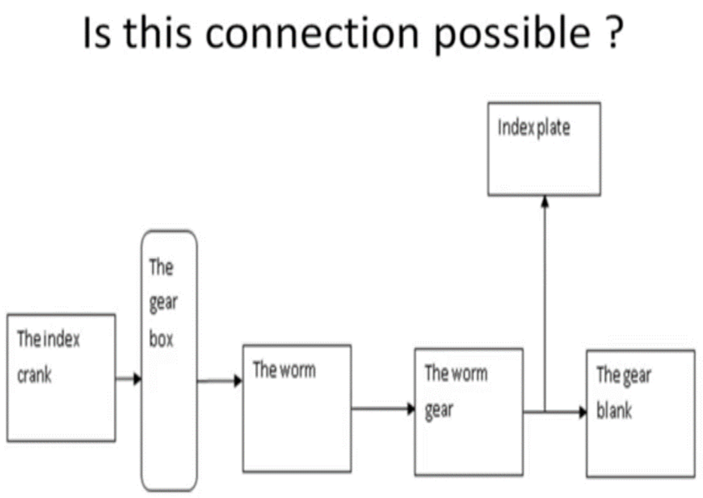

So, what do we have now? To start with, this one is what we have at present. This one is what we decided that this gearbox is not going to serve the 2 purpose of rotating the index plate properly and the index gear blank properly at the same time because they have different requirements of the value of the gearbox ratio if it is placed here.

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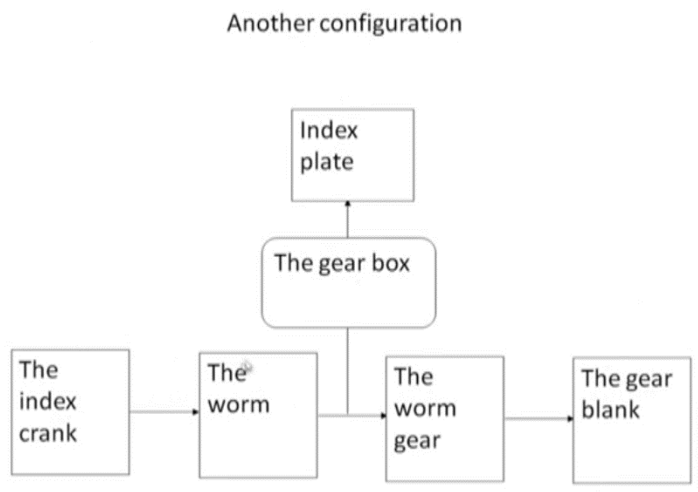

We also decided that this one is going to serve the purpose but every time it is going to ask for $\frac{1}{\text{number of teeth}}$ and that is going to ask for different worm and worm gear ratios perhaps for every different number of teeth you are cutting and it is going to be extremely expensive. So, this is what we have discussed just now U = $\frac{1}{70}$.

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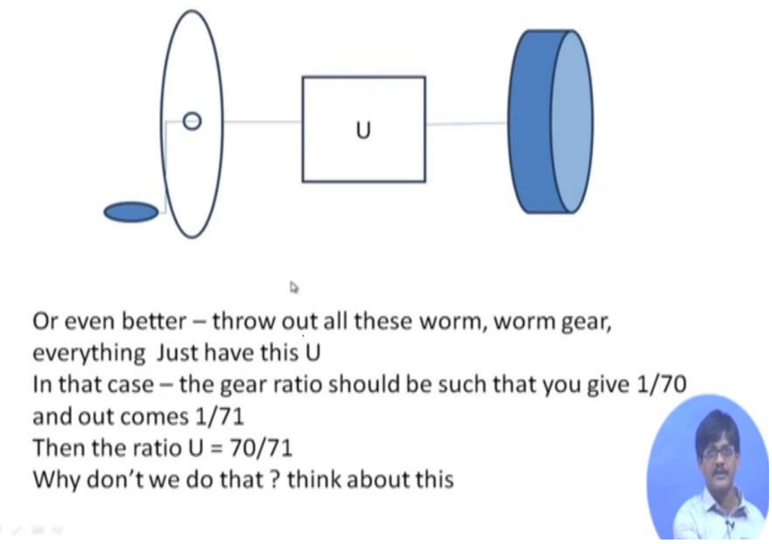

What if we throw out everything and simply we have a gearbox in which this will be the ratio of the number of available holes and the required number of teeth. That is, if you are cutting 71 teeth and you are having 70 index plate number of holes. This ratio will be typically $\frac{70}{71}$. Why did not we go for that? Remove everything in between and have that.

First of all, it will not give us that magnification of the input rotation which was helping us in reducing the errors. Secondly, this would mean that we would have to have a series of gears of successive numbers. $\frac{70}{71}$ will be required, $\frac{80}{81}$ would be required, $\frac{90}{91}$, $\frac{86}{87}$, a series of gears which will again make it extremely expensive.

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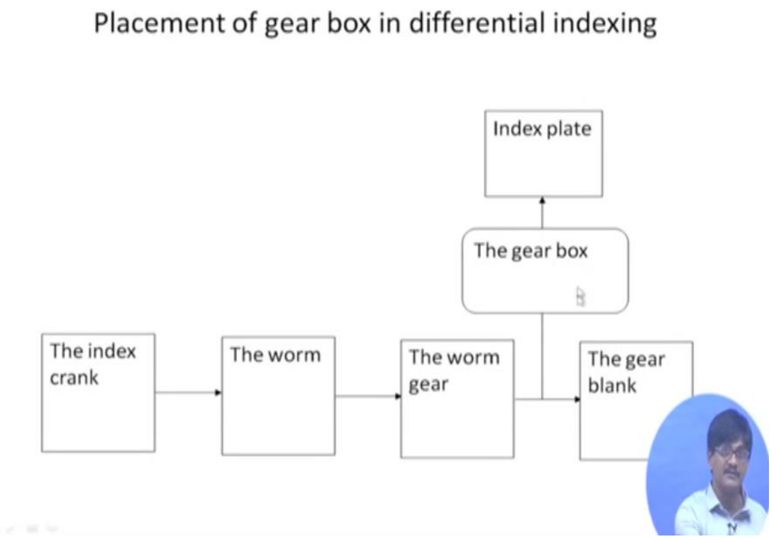

This is the reason why, the unique position of the gearbox in case of differential indexing is this one, none others. So, to sum up the full lecture, what we have covered is? First of all in the first week, we have covered the basics of gear ratios and introduction to different machine elements which will be required in case of gear cutting, like worm and worm gear, screw and nut, rack pinion, spur gears, helical gears, etc.

Everything we have discussed. So, in the first assignment, we have had coverage of those. In the second week, we have discussed about gear milling, helical milling, in simple indexing, differential indexing. And also we have discussed something about testing of gears by gear tooth Vernier callipers. I have left out other methods of gear testing because of dearth of time.

We have covered in the third week, the details about gear shaping process, gear shaping and we have also started a bit of gear hobbing in the third week itself. And in the last week we have covered gear hobbing, then some discussion about helical teeth. Some discussion about gearbox locations in case of milling and with that we come to the end of this course.

I wish you best of luck in the performance in the final exam and in the assignments. All the best. Thank you very much.