Production Technology: Theory and Practice
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Lecture - 29
Lab – 06

(Video Starts: 00: 21)
Hello and welcome to the course on manufacturing technology - theory and practice. Here we have the end milling cutter, and you can see that the colour is different; this colour is of the coating on the tool which increases the life of the cutter. The coatings are made with the titanium carbide of different kinds of carbides and coating is only about 5 to 10 microns, so that the tool life can be increased. In tool lip cutter there are 2 lips only and these cutters are also used popularly in case of milling operation.

This is the slitting saw cutter that we have already seen once. Saw cutter is a similar one but diameter is higher and those are the indexing plates that you can see here. We will show you the use of those indexing plates for cutting the gear; if you are cutting the spur gear, when the spur gear is made, one tooth is made after that there will be another tooth to be milled.

So, from one tooth to another tooth it has to be rotated, the blank has to be rotated, so how it can be rotated how much it has to be rotated that can be defined by the indexing plate and that indexing plate is attached to the indexing mechanism. That indexing mechanism will be used for making the helical and the bevel and the spur gear that we will be showing you in a short while. In this display, what you can see is the different kind of mechanisms through which the power can be transmitted.

Let us see here. This is the spur gear; this is a mechanism through which the power can be transmitted through the parallel shafts. Let us say these are the two shafts and they are parallel to each other. So, when one shaft is moving, another shaft is also moved and the transmission ratio depends on the number of teeth of these two mating gears. If you rotate this, this will be rotated at the fastest speed and if you rotate this, this will be rotated at a slower speed because then the transmission ratio will be this divided by this.

And in this case, this transmission ratio will be this divided by this so it will be faster and these are the two spur gears and each of these spur gears will be mounted on the shaft which are parallel, axes of these shafts will be parallel and the power can be transmitted. Now this is a positive drive, because there is no slip when the power is transmitted from this shaft to this, then there is no slip, so this is a positive transmission.

Here is the worm and worm wheel; this is a mechanism which is used for a very low transmission ratio. So, here the transmission ratio can go from up to 1:40. In case of spur gear transmission, as you have seen that if we rotate this gear will be rotated and it can be vice versa. So, you can rotate this gear, this gear will be rotated but, in this case, if you are moving the worm, the worm wheel is rotated. But if you rotate the worm wheel, the worm is not being displaced, not moved.

Therefore, apart from the advantage of having the 1:40 transmission ratio depending on the number of teeth here, another advantage of the worm and worm wheel will be that this is a locking mechanism meaning that if this is the driver, this will be driven, but this cannot be driver in this case. I give you an example of let us say, crane, when a crane is lifting mass or weight.

If power fails in between, had it not been the worm and worm wheel that is there, the weight it can be coming down and the mass they lift can be a concrete block or a full concrete block for room. So, they are very heavy and accident can happen or if you have seen the sliding doors, there also the worm and worm wheel mechanism is used. With 1:40 transmission ratio, very high torque carrying capacity can be imparted.

So that is the advantage of these kinds of mechanisms. The transmission ratio can be as high as 1:40 and the locking mechanism of the worm and worm wheel for which these are popularly used. Now, this is a mechanism which is called the rack and pinion mechanism. So, here also if you see that either you drive the rack, the pinion is driven or you drive the pinion and the rack is driven.

So, this mechanism is normally used for converting the rotary movement of the pinion to the linear movement of the rack or for converting the linear movement of the rack to the rotary movement of the pinion. Now, here if you have a shaft, on the shaft you can cut a rack like this and that rack can be engaged with the pinion. So, when the shaft is moving linearly, in that case the pinion will be moving accordingly and the shaft which is mounted along this axis that will also be rotated.

So, this mechanism is used for converting the rotary movement to the linear movement, the reciprocating movement and vice versa. And here is no locking mechanism as you can see that both can be a driver, pinion can be a driver, the rack can be driven or the rack can be a driver and the pinion can be driven. This mechanism differs from the worm and worm wheel. Now all these mechanisms, that is the teeth can be cut using the module gear.

Let us sayHere this is an example of the module gear and this module is 1.5, so this module gear is used to cut this kind of gears these gears where the module is 1.5 as well as this gear here also it fits in, so these gears are cut with the module gear. Here, if you see there is another mechanism which is the bevel gear mechanism and this mechanism is used to transmit the power between the shafts located at a 90^0 angle with respect to each other that I already told you while showing the bevel gear. Here if you see, both can be either driver or a driven.

So, here the shaft will be in this way, the gear will be mounted on the shaft and this gear can be mounted on the shaft like this, so these 2 wheels make an angle of 90^0. So, here if you rotate this this, bevel gear will rotate so in that case this is driver and this is driven or if you rotate this bevel gear, which is then driver, then this bevel gear also rotates and this will be in that case the driven gear.

Now, how these gears are generated, how these gear teeth are made? We will show you the machining of spur and bevel gears in the milling machine. You can see here there is one mechanism which is called the Geneva mechanism and the Geneva mechanism is something where the transmission is made intermittently. So, normally the Geneva wheel rotates at a constant speed and this is the driven.

Then in that case this Geneva wheel is the driver wheel and this is then that driven wheel. So, in this case as it is rotating continuously, the pin on the Geneva wheel will come in contact and enter the groove and then it will go out. During that this Geneva mechanism wheel rotates from one position to another position and then it will stop. So, we will show you another Geneva mechanism where it is working in the sense that it is given the drive to the Geneva wheel and how this mechanism works.

So, once again this is the driver, driver element which is the Geneva wheel and this is the Geneva mechanism. As this wheel is rotating continuously, it will get an intermittent motion. So, how it works we will show you in the Geneva mechanism. If you see here this is the ratchet mechanism, ratchet teeth on the face and this is the ratchet teeth on the periphery. So, both are ratchet teeth but this is on the face and this is on the periphery.

This is the ratchet teeth cutter and if you see that this fits in exactly well here and this is the mechanism, this is the cutter which is used for cutting the ratchet teeth on the face or on the periphery. So, this cut with an offset, not exactly like this is cutting here, this is mating here. So, this is the ratchet teeth milling cutter which is used for making the ratchet teeth on the face or ratchet teeth on the periphery, so both are the ratchet.

Now, here this is the chain and the sprocket mechanism that you must know because it is used very popularly in the bicycle, this is the driver wheel, here the pedals are mounted, pedals are attached. And if you are rotating that, there is a positive drive through the chain between the driver and the driven one and this on the driven wheel the shaft this is a shaft here and on that shaft the rear wheel of the bicycle is connected.

So, as you are pedalling, the torque which you are applying is being transmitted through the chain to the sprocket and through the sprocket it goes to the rear wheel of the bicycle and the whole bicycle moves. So, this is how the mechanism works that means the chain and sprocket this is the sprocket wheel, this is the bigger wheel this is the smaller wheel and this is the chain which connect both the wheels.

So, this is the sprocket cutter, this is used as a milling cutter and this is used to cut the sprocket as you can see that this completely matches with the profile of the sprocket here. So, this will be used for cutting the sprocket teeth this is the milling cutter. As I was telling you about the Geneva mechanism, I would like to demonstrate this Geneva mechanism and how it works. So, this is the Geneva wheel and the pin, this pin rotates continuously with the help of a motor.

This motor is attached here and while it rotates this pin enters in the groove of this Geneva mechanism and then while entering and exiting this rotates from one position to another position and then it stops for some times when it completes the other rotation. Let us see this for example, if we switch on the power, you can see that, so this pin is entering and exiting. So, when the pin enters and exit, it rotates from one position to another position and then during the rest of the movement of the pin this stops.

So, as you can see, this is rotating continuously and this rotation is made by the motor which is attached with the shaft of this wheel. And when the pin once again pin enters the Geneva mechanism and exit during that time it rotates from one position to another position. Let us see how and where it can be actually used. So, since it is rotating continuously on this shaft of the Geneva mechanism, you can mount a rotary table and on the rotary table you may have the assembly mechanisms in these positions.

When the pin enters into this groove and exits, it will move from one position to another, then during the other part when it is moving for the rest along the diameter then the assembly process will be made because it is not rotating, it is stationary. That is called the dwelling. So, it will be indexing and dwelling with the continuous rotation of the pin. This is the advantage of the Geneva mechanism and this translates the continuous rotation of the driver mechanism to the intermittent motion of the driven mechanism.

In this case this is the driver mechanism and this is being driven so this is the driven mechanism and this driven mechanism will be rotating intermittently it will rotate and stops for some times when the pin completes the other rotation then again, the pin enters to this groove and exiting during that time it is rotating from one position to another position. So, this is the advantage of the Geneva mechanism and these kinds of mechanisms are very popular.

They are used very popularly in the industry for transmitting the continuous movement to the intermittent motion of the driven mechanism. Now we will demonstrate you the functioning of the milling machine, here we have the horizontal milling machine because as you can see that this is the axis of the milling cutter and the axis of the milling cutter is horizontal. So, as I said that is axis is horizontal so, that milling machine will be called as a horizontal milling machine.

Now in this horizontal milling machine you can mill the surface, that means, you can make a flat surface, you can make grooves, you can make the slots as well, and you can cut the gears. For making the flat surface, the milling cutter will be mounted in the arbor and we will show you how the milling cutter can be mounted, in that case the workpiece has to be mounted on the vise, the vise has to be separately mounted on the table of the milling machine and that I will show it to you while describing the vertical milling machine.

And then the arbour will be tightened with the milling cutter; here are the spacers, we have seen that arbour separately in the tooling section. Now here while the cutting the teeth, either it is a spur gear tooth or it is a bevel gear tooth, we use an indexing mechanism and the indexing mechanism is also called the dividing head meaning that you divide the number depending on the number of teeth.

You rotate the blank of the gear at that angle for getting the position for cutting the next tooth on it. So, this is called the dividing head or indexing head, here the transmission is given through the worm and worm gear and the job or the blank will be mounted here on this. So, this is the transmission or the rotation to the blank given through the torque carrier with the help of this attachment which is attached to the dividing head and this is mounted in this way.

And then the job will be mounted somewhere here in between here with the help of the spacers and this another end will be coming to this and this will be moved and on the centres. So, job will be on the centres we will show it to you now and the gear can be cut, after cutting one tooth, this has to be operated so that the position for the next tooth can be found out and that can be found out with the help of these plates.

We have already shown you some of those plates, so there are 3 plates, plate 1, plate 2 and plate 3, so each of these plates has to be selected depending on the number of teeth that you are cutting. Let us say if we have 20 teeth to cut, so for that there is a plate which according to our chart, is the plate number 1. So, plate number 1 can cut 15, 16, 17, 18, 19, and 20 from 15 to 20 teeth for cutting 15 and 20 teeth, the plate number 1 has to be selected.

It has the holes here and that hole has to be engaged with one of these holes along the periphery of the wheel of the plate. And the formula for that is the number of teeth that you are cutting divided by 40. And divided by 40 because inside there is a worm and worm gear mechanism as we said. Through the worm and worm gear mechanism this rotation is given for the blank. The blank is rotated from one position to another position of the tooth.

And if it is worm gear, we will show you how this 1:40 can be obtained, it is the simple mechanism which is inside the indexing or the dividing head. So, here this is the pin, that is the plate that we have shown it to you, now the plate is rotated and the axis of this handle is connected to the worm mechanism worm here and the worm is connected to the worm gear which has 40 teeth. So, here the formula will be 40 divided by n, 40 divided by n means that n is the number of teeth that you have to cut.

Now, depending on the plate we have the plate 1 where you have 15, 16, 17, 18, 19, and 20 these are the number of teeth that will be cut using the plate number 1. So, in that case suppose you are cutting 20 teeth in that case this will be 40 / n, so 40 / 20 is 2 that means it needs 2 complete rotations of this so that one tooth will be displaced, spacing will be one tooth so, you have to actually cut the next tooth, therefore, 2 complete rotations for cutting 20 teeth.

Let us say for cutting 18 teeth in that case the formula applied is $\left(\frac{40}{18}\right)$which will be 2 rotations and (4 / 18) and (4 / 18) means that 2 complete rotations then out of 18 there are 4 holes have to be moved. So, we will show you here in the real mechanism which is attached to the milling machine and show you how this indexing can be done, so that when the teeth are cut, how we can get the next position of the tooth to cut.

Now we are going to show you how we are going to make spur gear like this using this machine and dividing head. So, this is the drawing of the spur gear that you can see here, here there are a number of teeth let us say 20 we will cut and these the side view or rather the view along the A-A section that you can see here all the dimensions are given here. Now the blank has been already made and this blank is fitted here in this arbour.

So, accordingly this outer diameter if the number of teeth is 20 and let us say module we will take as 1.5. This is the module is 1.5 then there is a formula that the outer diameter will be

$m(n+2)$ *m* is the module and *n* is the number of teeth. So, number of teeth will be 20, (20 + 2) is 22 into *m*, *m* is the module 1.5 which makes it 33. So, the outer diameter has to be 33 mm which has been selected and this is the blank which is made in the lathe. So, it is already turned and the blank is mounted on this mandrel.

Now, the rod diameter, means which goes inside of this blank, i.e. which is the inside diameter of the blank, inside diameter of the blank has been given as the 12.7 mm let us say we have selected to enter 12.7 mm. And the depth of cut formula that how the depth of cut will be given depth of cut for the tool that is a milling cutter. This formula is given as the 2.157 multiplied by module. This is the standard formula for the spur gears. So, 2.157 into module is 1.5 selected, so that will make you 3.24.

Therefore 3.24 mm depth of cut has to be given to the tool for making the 20 teeth here along the periphery of this blank, indexing formula I already told you that is *(40 / n)*, *n* is 20 so (40 / 20) = 2. So, therefore, it will be a 2 complete rotations of this plate that will make the indexing, that means, from one tooth to another tooth, how to space the one tooth and the next tooth when it will be cutting it has to be moved 2 complete rotation because this is 40 / n, n is the number of teeth which is 20 so 40 / 20 is 2.

And then that tap hole size is 5.2 mm drill and 1 / 4 inch of the tapping so these are selected so, that all the other operations are completed. Now Mr. Aman Singh will show you how to mount the mandrel between the centres and then how to mount them on the milling cutter, on the arbour and then how to cut the gear and how to index for cutting the next tooth. So, in this display you can see the different milling cutters.

So, these are all the standard milling cutters and we have to select one of these depending on the specification which are given, for example this milling cutter is used for cutting 135 number of teeth, 135 or more for example for cutting the rack. In rack that number of teeth will be much more depending on the length. So, they are this kind of milling cutters are used for cutting a number of teeth 135 or more.

This milling cutter, can be used for cutting 55 to 134 number of teeth, number 3 so, this is number 2 these are all standard milling cutters as I said, number 3 is for cutting from 35 to 54 number of teeth, this milling cutter for cutting 26 to 34, this milling cutter for 21 to 25 and this for 17 to 20 this for 14 to 16 and this milling cutter can be used for cutting from 12 to 13 number of teeth. Now this is based on the pressure angle because the teeth of the milling cutters have to meet.

So, if the pressure angle is different in that case there will be different cutter, so, all the gears where you will have the 20 teeth, we are going to cut 20 teeth, this is the milling cutter that has to be selected for cutting the spur gear with the 20 teeth meaning that if you are cutting 2 spur gears of 20 teeth for both you have to use this milling cutter, otherwise they are not going to match because their pressure angle will be different if you use the other milling cutters.

So, this is the basis on which one or the other milling cutters are used that is the pressure angle. So, we will be using this milling cutter which has to be mounted on the arbour of the milling machine that Mr. Aman Singh will be showing to you. Here Mr. Srinivasalu is demonstrating how the milling cutter number 6 is used, because this is the milling cutter that has to be used for cutting 20 teeth.

He will show how the arbour can be removed and how the milling cutter can be mounted on the arbour. Here this is to be removed, this is the arbour support and these are the spacers which have to be removed for mounting the milling cutter. Now the milling cutter has to be mounted on the key. Key is there you can see that and key here it is, this will be mounted on the key. So, this will be on this side because it will be up milling.

Up milling means the rotation of the milling cutter and the rotation of this the blank will be opposite. So, this is normally called up milling and here we normally do the up milling because down milling is not appropriate for this situation that I will describe in details in the lecture in our next classes.

So, this is the spacer on the arbour and then finally the nut has to be put on the arbour and this is the support, when it is tightened as you can see that the milling cutter is rigidly fixed on the arbour. So, there will be no movement related movement between the arbour and the milling cutter. Arbour will be moving along with the milling cutter with the same speed and arbour is mounted on the spindle of the milling cutter. That on the milling cutter table is the vise on which the part will be or the blank will be mounted between the centres.

You can see that there is a dead centre there and here is the job which has been mounted, this is the dog carrier, the dog carrier is attached to that arbour or mandrel on which the workpiece is mounted and the workpiece is here this is the workpiece on which the gear will be or gear teeth will be cut this the whole attachment with the dog carrier is mounted between the centres, one centre one end will be attached to the dividing head and another is on the vise.

Now this vise is to be fixed on the milling cutter table and it can be fixed only when the dead centre is attached to the arbour, to the mandrel, mandrel with the workpiece, it is tightened. So, now it is ready for cutting the gear. Now you have to set the plate of the indexing device or dividing head. So, I will remind you once more that there will be 20 teeth to cut. So, here this is the plate on which you can see that these are the along the periphery there are different number of holes.

So, since we have to rotate 2 complete rotations, so this pin can be attached to any of the holes. But overall, the disk has to be rotated 2 complete rotations so that the blank rotates by 1 tooth. Because as we said that the formula is $(40 / n)$ and the n in our case is 20. Therefore, 40 / 20 is 2. So, this 2 is meaning that 2 complete rotations of the plate so that one rotation or rotation by 1 tooth can be made for the workpiece.

So, before we start cutting the gear teeth, first of all this has to be centered and centered because the milling cutter has to be centered because these are straight teeth. Now, if it is not centered then the offset will be made and then then the accuracy of the gear will be lost for that here it has to be made in the 0 that means, in this scale if it is 0 so, it is exactly at the center then it will be touching the workpiece here.

When it is touching this has to be made as 0 that is the 0 point here, then from that 0 point here it will be fixed somewhere which will be 0 indicating 0 point and then 2 complete rotations have to be made for the next tooth to cut. Now the machine is on you are touching the milling cutter with the workpiece which will indicate it is exactly touching. So, this will indicate the 0 position, I will tell you make it now, it is the 0 there as I said then here. So, it is the 0 position according to the 0 position this has been fixed.

So, 3.24 is the depth of cut that we have calculated, so that depth of cut is given by this scale that would be in one pass, 3.24 that is given; 3.24 is in mm which is the depth of cut, this much material will be removed by the milling cutter. Now the coolant is on and the gear cutting will take place, the feed is given manually. And as you can see the feed is given, feed means the movement of the table along with the workpiece so that the full length of the gear can be cut, tooth is completed, you can stop the machine.

So, we have to now rotate twice this plate for the next tooth, so that means with the two complete revolutions of the plate, the gear blank will be moving from one position of the tooth to the next position of the tooth. Worm and worm gear, I will remind you that it is inside the indexing mechanism, the dividing head. So, now it is the next position of the blank and the next tooth can be cut.

So that is the second tooth that has been cut and then rotate it the same way again by two complete rotations of this plate, then the position for the third tooth will appear and the third tooth will be cut. So, if we continue doing that after the second tooth you make two rotations of this plate. That way the plate will move from one position to the next position and the third tooth will be cut and you continue doing that, in that case your complete finished product will be like this.

So, this is the gear that has been made here; similarly, that we were demonstrating and there are 20 teeth according to the drawing that I have shown and here there is a threaded hole after that after the drilling and the tapping this hole can be made; there is a central hole here that has already been made earlier and this is the complete finished product that can be used. You have so far seen the gear cutting process, gear cutting technology we have described in details and that was done on a horizontal milling machine.

So, here we have told you how to make those calculations. I have also shown it to you in a power point presentation and the entire process, entire technology has been described and has been demonstrated to you. Today we will show you the technology of the gear cutting for the bevel gear. So, we have shown you earlier what is the difference between the straight gear or the spur gear and the bevel gear. So, today we will show you how these bevel gears are cut.

And then we will understand the difference in this technology. Before that I would like to tell you that for the bevel gear we will be using this drawing and this has been shown to you in the power point presentation as well. So, you can see all the dimensions here I mean, what kind of dimensions or what kind of measurements that you have to take for the bevel gear and we have to make a small calculation before the teeth cutting like in the case of the spur gear.

First of all, we have to find out what is the shaft angle; shaft angle means that when the bevel gears are connected with each other, two bevel gears are connected with each other, these shafts, as I said to you, that they make an angle of 90^0 if they are normal bevel gears but there are bevel gears where the shafts may make an angle which is different from the 90 degree angle. So, that angle is called the shaft angle, module is m, pressure angle is α and the number of teeth we are deciding.

So, here for example the number of teeth that we have decided is 30; earlier we have demonstrated for a spur gear of 20 numbers of teeth. So, here we are demonstrating the number of teeth is equal to 30 that we have decided. Now the pitch diameter formula so, to find out the pitch circle diameter we have a formula of $\left(Z \times m\right)$. So, Z is the number of teeth and that has to be multiplied by the module m.

So, in this case for the pinion our D 1 is 45 and for the gear the D 2 is also 45 because we are making the number of teeth 30 and module is 1.5, so that makes it 45. Now the pitch cone angle will show you the pitch cone angle in the drawing and this can be found out with a formula of tan inverse of sine angle some angle and that angle is the shaft angle divided by $\left(\frac{Z_2}{Z_1}\right)$ + cos of the shaft angle.

There is a particular formula that can be derived and that formula can be used to find out the pitch cone angle and in our case the pitch cone angle has come out to be 45^0. Now the cone distance this is given by a formula this is D 2 divided by 2 of the sin of the angle so, that has become 31.82^0; phase width that should be less than some value or 10 meters less than 3 or 10. So, this has become 10.6, this is the phase width also the phase width you can decide.

For example, you want the phase width to be this, so, there is a recommendation in practice this phase width cannot be less than something and more than something so that is what we said to you. Addendum is 1.5, dedendum is 1.875 that the addendum dedendum concept that addendum is that difference between the maximum diameter and the pitch circle diameter whereas the dedendum is the difference between pitch circle diameter and the lower diameter minimum diameter.

Then similarly they dedendum angle addendum angle outer cone angles, so, for everything there is a formula and according to that formula for example in case of addendum it is 1 M, so which is 1.5 M stands for module, dedendum is similarly 1.25 module so that has become 1.875, module being 1.5 and so on. So, we have to make all those calculations and get them ready the values we have to get them ready to set the machine.

Now here we have the horizontal milling machine again, so similar to that machine although this machine is different from the one that we have seen earlier for the spur gear cutting. So, here we have the spindle, on the spindle we have the arbour and on the arbour we have to fit the milling cutter, the milling cutter that we will be using will be from that table, from that chart that we have seen from where we have selected the milling cutter for cutting 20 gears.

So, today we will be selecting a milling cutter for cutting 30 gears so from that table we will select the particular milling cutter, that will be mounted on this arbour with the help of the spacers. Finally, it will be tightened by this nut and then we have the dividing head and the principle of the dividing head we have shown it to you for the spur gear cutting. So, accordingly we will be using the diving head with the help of the plates and the principle remains the same.

So, here the same formula will be used, that is *(40 / n)* that is what we said that how many rounds we have to rotate for this. So, for example for cutting 30 gears it will be 40 / 30. So, this will be 40 / 30 means 1 and remaining will be 1 / 3 so, 1 / 3 can be said to be 6 / 18. So, suppose we have 18 holes in the on the periphery we selected the 18 holes the pitch circle diameter out of the 18 holes we have to move to 6 holes. So, 1 full rotation and another 6 holes with that 18 holes pitch circle diameter.

So, this principle remains the same as in case of the spur gear cutting. So, once again, for example for cutting 30 gears it will be same formula will be used 40 / N. So, it will be 40 / 30 which is 1 and 1 / 3. So, 1 / 3 we are taking as 6 / 18 and therefore, the 6 / 18 does mean that you take the plate and when there are 18 holes out of those 18 holes where the pin is set to the pitch circle diameter where there are 18 holes along the diameter and out of those 18 holes you select 6 holes and move further to that that angle.

So, that will make you the indexing for cutting 30 gear teeth in the 30 bevel gears so that will be showing. So, let me tell you a little bit about this machine; we have the machine bed on the bed we have the dividing head here we have the support for the longer jobs so, the workpiece will be mounted on this, on the dividing head and it has a 3 jaw chuck, on the 3 jaw chuck we are mounting this. So, before we start cutting gear, we have to make the blank on that in the turning lathe.

So, because all these surfaces have to be turned and then on this conical surface the bevel gear teeth have to be cut. So, in this horizontal milling machine, we have the handles for the cross feed, this is for making the table up and down and here is one more handle you can see that this is for the longitudinal feed. So, the mechanism is similar and this machine actually will be taken as a horizontal milling machine for cutting the bevel gear.

We have Mr. Srinivasalu and he is going to operate the machine and he is going to cut the bevel gear and show you the entire cutting process. This is the milling cutter that we have selected for cutting 30 gear teeth and that has to be mounted on this arbour, first this has to be removed, arbour support, this is familiar to you.

Because earlier also for the spur gear cutting, we have shown you the similar process that how this milling cutter has to be mounted these are the spacers that are being removed from the arbour so then with the help of the key and this is the key way in this key way the key has to be set and this key half of that will be inserted in the arbour key hole of the arbour. So, here is the key, half of that key has gone into the key slot of the orbit and half of it has gone to the milling cutter.

So, the milling cutter is now rigidly fixed with the arbour, meaning that it cannot move with respect to the milling cutter it cannot rotate with respect to the milling with respect to the arbour but it can move axially. So, to stop that movement we have the spacers, these spacers will prevent the axial movement of the milling cutter. So, now when we have enough number of spacers and tighten that with the nut here.

So, in that case, the milling cutter is rigidly fixed it cannot have any kind of relative movement between the milling cutter and the arbour that is the basic purpose of it all these are spacers. So, this will be tightened and then this support will be held here, do it cutter is fixed now. Now I have to select the RPM so a certain RPM has to be selected because that on that has been determined by the calculation and here, we have the 114 this is the RPM of the spindle of the arbour.

Now we have to set the blank and the cutting angle so, first of all the root cone angle and the root cone angle as I said has been calculated and it has been found out to be 41.63 degree, you can see that here there is a dial and that dial is graduated. So, using this graduation of the dial we can actually set that particular angle which will be as the root cone angle 41.63 so, this cone is 1 degree so, we can go 41.

So, now it is this angle is set at an angle of 41.63 which is the root cone angle because at that angle the teeth will be cut on the bevel gear teeth will be cut now it is being tightened and it will remain at this angle; so, before we start cutting the bevel gear we have actually with the help of these handles of the longitudinal feed making the table up and down. So, you can see that the gear is almost touching the blank now we have to fix the rotation how many rotations for indexing.

So, this is the indexing mechanism in this indexing mechanism we have to fix the number of rotations how many numbers as I said that that will be 1 and 1 / 3, 1, 1 / 3 is 1 and the 6 of 6 / 18 so that is one full rotation and the 6 of these holes out of 18 holes. So, you set the 0 this is just for convenience of moving so, this is the sector arm that sector arm has been set in a position where there are 6 holes we can count 1, 2, 3, 4, 5 and 6.

So, it is set at the sixth hole and then it will be fixed, that is the fixing of the sector which is now set at 6 holes out of 18. Now it will be ready for indexing, we know that we can rotate one complete rotation and those 6 holes where that sector is fixed, so up to that sector it can go. Now we are going to touch on the top surface of that so you will start the machine. Now, we will activate the handle which will lift up the workpiece which is mounted on the dividing head.

It is brought to the contact of the milling cutter, it is touching the top diameter for surface of the workpiece. So, the depth of cut is now has to be given. That depth which has given, has been decided by us. So, you can decide what will be the depth of cut according to the requirement of the gear that you are cutting where the gear will be working, so now it is in the automatic mode and according to the depth that has been given, the milling cutter we will remove the material and cut one tooth on the blank.

I can see that the chip is being removed. Well, one tooth has been cut and the tool is being retracted, that is the dividing head along with the workpiece has been retracted from the milling cutter. And then the indexing plate will be used for indexing that is to come to the position where you have to cut the next tooth. And for that, we will be rotating 1 complete resolution of the disk of the plate and the 6 holes as a set out of those 18 holes that will make you 1 / 3.

So, it will be 1 and 1 / 3 that is 30 divided by 40, 30 gear cutting and the formula is the same as in case of spur gear cutting which is 40 / n. So, it will be 40 / 30 which is 1 and 1 / 3. So, this is the gear and now the blank is in the next position for ready to cut the next tooth and now the milling cutter has started removing material in the position where it is next tooth is being fabricated, well both the teeth have been cut stop the machine.

Similarly, when all the teeth will be cut and cutting process will be the same meaning that when one tooth is cut, then you have to use the indexing head to rotate to come to the next position. Then again rotate the same way that means one complete rotation of the plate and 6 holes out of those 18 holes which will make you 40 divided by 30 because 30 teeth we are cutting and this is the final product that you can see that has been fabricated in this machine. So, all the 30 teeth are being fabricated and this is the complete bevel gear that was required as per the drawing that has been given. Thank you for your attention.

(Video Ends: 01:03:10)