Production Technology: Theory and Practice
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Lecture – 32
Lab - 09

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Hello and welcome to the course on manufacturing technology- theory and practice we are now going to demonstrate the working principle of grinding machine and overall, I am going to give you an idea about the grinding, although you have listened to some of the grinding theories in the lecture sessions, but nevertheless here is the grinding machine. Particularly this grinding machine is a tool grinder we call it because in this lab we need to grind the tools.

However, we can also make the surface grinding to grind the surface as well as we can make the grinding for the drill which is very important for our lab. You can see this is the spindle of the grinding machine and this mandrel of the spindle the grinding wheel cup type grinding wheel is mounted and here we will have the tool that is to be mounted. First we will show you the grinding of the side rake angle; this is the turning tool.

This is the rake face of the tool and the inclination of the rake face that is defined by the side rake angle that we will show you; that means this is the angle between the rake face and a line which is this line perpendicular to the cutting velocity vector. This angle between this scale edge and this surface which is the rake surface, this angle will be the side rake angle you can see that there is an angle.

And you can see that there is a certain angle between the edge of the scale and the surface of the tool which is the rake face, which is the side rake angle. This side rake angle will define the inclination of this rake face and as I already told you in the lectures of the course that the side rake angle is one of the important angles because the side rake angle also defines the cutting power and the cutting force.

Meaning that if the side rake angle is changed, the cutting forces will be changed and ultimately the power will be changed, so, those details have been given in the in the lectures that you can see those lecture sessions. We will show you how this angle can be ground. Now why we need the need to grind the angle? The tool as you know that when it works the surfaces wear out. This is the rake face where the wearing takes place in the form of a crater wear.

And this is the flank surface which wears out because of the flank wear and it is due to the rubbing of the flank face with the already machined surface and the crater wear that takes place on the wreck face is because of the tool because of the chip sliding along the rake face so there will be a crater form which will be some distance away from the tool tip. Those details are given in the lectures.

Now coming to the grinding, apart from this kind of a grinding wheel, you can see another grinding wheel, it can be like this or a grinding wheel for the profile grinder module cutter for example we grind it with this you can see that this is a thin grinding wheel, this is made for the profile for grinding the profile. It will be inclined to this one profile and then it will be inclined to this so it will be another profile and so on.

Another grinding wheel is the cup type grinding wheel. These are all mounted on the mandrel of the shaft of the spindle, the grinding wheel which rotates and the grinding wheel rotates which actually is the cutting speed. Now, another grinding wheel you can see is this kind of a grinding wheel. These are also used for grinding the tool angles, different kinds of tool angles. Now regarding the grinding wheel, I will just remind you that there are 5 parameters which actually define the working of the grinding wheel.

Now if you see the grinding wheel the first parameter that you can see which is the type of the abrasive material; basically there are 3 types of abrasive materials which are used. I am repeating once again, details you can see in the lecture material. So, either it can be Al_2O_3 aluminum oxide, silicon carbide or the diamond. Aluminum oxide, silicon carbide and the diamond are used depending on what kind of workpiece material is ground.

For example, for the grinding of the steel or high strength material, the aluminum oxide, Al_2O_3abrasive grains should be used. Silicon carbide is used as the grains of the grinding wheel for the materials like aluminum, copper or brittle material like cast iron or hard materials overall. That is the workpiece material they are used to grind with a grinding wheel with silicon carbide grains.

Now the silicon carbide grains are more expensive than the aluminum oxide grains and the diamond grains are exclusively used for very hard materials like you know glass or the hard materials like UCON and so on which are used these days for the tool materials. For sharpening those kinds of tools you have to use the diamond grinder. Now the diamond grinders are very expensive because the grains will be the diamond grains.

And they are used for exclusively for very hard and brittle materials like glass thatcan be ground only by using the diamond grinding wheels. The second parameter on which the performance of a grinding wheel depends is the size of the grain, either you use coarse size that is the bigger size grains or you can use the medium size grain or you can use a fine grains and very fine grains.

These are the 4 basic grades which are available, that is coarse, medium, fine and very fine grains. Now the diameter of the grinding wheel grains depends on this sieve number. The sieve number defines the size of the grinding wheel grain that sieve number is given by S_n , more the S_n value less will be the diameter. There is a formula according to that you can find out that what can be the diameter of the grinding wheel.

Basically this is inversely proportional to the sieve number and the sieve number as I said in my lecture class that this is defined by and 1 inch by 1 inch sieve and how many openings are there by 1 inch and 1 inch sieve; if the openings are let us say 600, in that case the abrasive grains which will pass through that kind of a sieve will have an S_n number of 600 and the diameter will be proportional to that that is $1 / S_n$ that is 1 / 600.

So, you can understand that those diameters will be very fine. Those are the very fine grains. Now, where those kinds of grains are used? As I said earlier in the lecture material also that very big grains are the coarse grains which will remove more material because the grains are very big. And since they are removing more material, then the surface finish will not be very good. Surface finish will be good if the grain size is small, when the material removal rate is less, less material is removed.

If the number of grains or the size of the grain is very big in that case the number of grains will be limited they will be smaller number because the grain size within a given diameter the grinding wheel will be bigger size so the number will be less. The third parameter on which the performance of the grinding wheel depends it is the grade and the grade defines the strength of the bonding material. How well the grains are bond with each other.

When the grinding wheel will be working, each grain inside this grinding wheel is bonded and that is done by a resin, some kind of a resin there are different kinds of resins used for this purpose. And how strongly those bonds are and how strongly the grains are bound to each other, depending on that the strength of the grinding wheel will be defined.

Meaning that if the bonds are very strong then the grinding wheel grains will be very strongly, very rigidly bound with each other and it will not be easily dislodged. So, in case the grinding wheel is hard, in the sense that grinding wheel bond is very strong and you are using suppose very hard material for grinding workpiece material for grinding, that may create problem.

Since the workpiece material is very hard then grains which will be on the surface of the grinding wheel will be worn out very quickly because the material of the workpiece is very hard. Now, if the wheel is very strong then those worn-out grains will not be easily dislodged and they will stay on the periphery on the surface of the grinding wheel. What is the problem with that that? They will stay at the surface.

And they will not allow the other sharp grains to be revealed which are below them. Therefore, those worn-out grains they will start removing material and as you understand that since they are not sharp, they will rub more, they will consume more power and they will consume more force, without removing much of the material. So that is a very negative factor for the grinding process.

And in that case, it is said that the grinding wheel is glazed that is called the glazing of the grinding wheel, because those worn-out grains which will be on the surface of the grinding wheel which are not coming out, they will make the grinding will look like a glazed surface, those glazed worn out grains or the glazed layer has to be removed forcefully.

And that removal is done by a diamond pencil that process by which this is done is called the wheel dressing, so wheel dressing is nothing but removing those worn-out grains from the surface of the grinding wheel when particularly the grinding wheel is very hard and those worn out grains do not dislodge from the grinding surface very easily. Now the next parameter on which the grinding wheel performance depends is the structure of the grinding wheel.

Now by looking at the grinding wheel you can say that the grinding wheel is very densely packed or it is very loosely packed in the sense that the voids between the grains will be smaller; voids are those spaces between the grains like in the case of milling cutter, for example, in milling cutter between the teeth there is a space and that space is provided to accommodate the chips.

Similarly, in case of grinding wheel also in between the grinding wheel grains there is a space and that space is given for accommodating the small chips the . Now if those voids are very small and the grinding wheel chips are very small anyway, then those chips will be staying in those voids and would not be able to come out.

Then what will happen is that all along the surface of the grinding wheel those chips will be nested and instead of the grains removing the workpiece material, the nested or clogged chips will be rubbing and that will also consume more power it will rub and the force will be taken more without removing much of the material. So that is also a negative factor like in case of the wheel glazing but in this case, it is called the wheel loading that the wheel has been loaded.

Again, those chips which cannot come out because the voids are small, they have to be forcefully taken out and again the wheel racing is required like in case of the glazed wheel. There are 17 structures of all the grinding wheels and that is an international standard all over the world. These 17 structures are used from 0 to 16, 0 is dense to open is 16. Altogether there are 17 structures 0, 1, 2, 3, 4 these are very densely packed grinding wheels.

And starting from 8, 9, 10, 11, 12 and so on up to 16 they are loosely packed, meaning that the voids are very big and the bigger chips can be accommodated there. So that is for rough operation, where the chips are bigger in size and to accommodate those chips in the void so that they could come out, those voids have to be bigger. Finally, another parameter on which the performance will depend is the bonding material.

There are different kinds of bonding materials, some of the bonding materials are vitrified bond, resinoid, shellac, rubber, metal bonds and so on. Silicate is another bond which is very interesting bonds which are used for cool operation, meaning that when you are using the silicate then that bond will allow you to make the grinding will softer in the sense the grains will be dislodged easily.

That means if you have a very hard material and if you are using the silicate bond in the grinding wheel, then the worn-out grains will be easily dislodged and those grinding wheels are used for grinding the small space in the tool because the only the tooltip has to be ground for example tooltip has to be re-sharpened, in that case you do not want the very high temperature to be produced, so that the vicinity of that tip is not thermally deformed.

In that case you have to be very sure that temperature rise is not much and since in grinding the grinding velocity is very high which is 10 to 80 meter per second and you can understand that 10 to 80 meter per second is a very high speed and at that speed the temperature occurring will be very high. You will see here that when the grinding process will be on, there will be those chips which are so small and they will be flying away in terms of the sparks.

You can see the sparks, they are actually burning, temperature may go up to 1500^0C. At that temperature, those small chips which which are of the work material can actually burn. Therefore, we do not want the temperature to rise very high and temperature may not rise very high when the cutting is done by the sharp edges and not by the dull edges because as I said the dull edges will rub more, it will produce more temperature.

The silicate is one bond which is used for the cool operation so that during the grinding process the temperature does not rise very high. These are the 5 parameters which are very important for any grinding wheel that you take, be it a tool grinder, be it a surface grinder or be it a wheel grinder, the performance of the grinding wheel overall should be controlled by controlling these 5 parameters together then only your result or the grinding process will be effective, grinding process will be accurate.

Here in this we are going to show you as I said the grinding of the tool. I will repeat that during the cutting process these surfaces will be worn out particularly the rake and the flank surface and the angles that you provide initially for the sharp tool, will be distorted. Now as those angles are distorting in that case the force requirement, the power requirement will be changed and therefore those angles have to be restored.

For restoring those angles to the previous values that you have selected, you have to re-grind the tool and now we will show you how a tool can be reground, so that the worn out surfaces are established or compensated for and the initial angle that you have selected can be established. Mr. Aman Singh will show you how this tool can be reground or particularly this side rake angle as we said and I have shown you the side rake angle here so this angle particularly will be restored and reground.

So that the angle obtained will be as per the initial value that we have selected. The worn-out tool is clamped in the vise which in this case is the tool post and the grinding wheel mounted in the mandrel. Now initially you make the 0 point that is you touch the grinding wheel with the surface that you are going to grind.

And the speed can be selected by the selector, it is there in that machine by which you can select different kinds of speeds that is required here. Now you can see that what is the speed of the grinding wheel; it is rotating at a very high speed and at that high speed the grinding process will be performed. So that is in in touch with the rake face of the tool and the side rake angle will be established, you can see the spark.

That spark as I said is nothing but the small chips being burned at the temperature of up to 1500^0C that tool material is the high-speed steel material. He is giving the feed manually and it has to be given very slowly, the feed rate should be very small it will be about 0.2 to 0.6 meter per second not more than that, in this case the setting of the tool is very important.

So that the grinding process can be performed to get that particular rake angle, if you incline the tool for example, the rake angle which will be ground it will be distorted it will not be the same rake angle as you have initially selected and that angle that you require this angle set as I was telling the tool has to be set very carefully this angle is selected by this dial, this dial is graduated and it can be rotated, so that according to that angle, which you require that angle can be given here.

So, it is not simply mounting the tool, but mounting the tool at a certain angle at which the side rake angle that you want to regrind that can be established. This is important as I said that that angle cannot be arbitrary angle. You can see that this looks a little burned because at a high temperature there is burning tendency and that is why this is hot.

And this color came because of the burning of the surface too and to a certain extent. However, this does not make thermal distortion of the vicinity of the tool. However, if at a very high temperature it happens then it may be distorted meaning that other angles may be distorted. That has to be protected therefore, we need to have a grade which will be softer, that can allow the grains to dislodge.

So that sharp grains can always remove the material and temperature occurring could be less. I gave you an example of silicate as the one that is an example of making a softer wheel. We are going to demonstrate another grinding process which is the grinding of the drill. Now, you can see this drill. We have to grind these 2 faces, and these 2 faces together they make an angle of 118^0.

This is the cutting angle of a drill which is a standard value. Between these 2 faces, this angle is the cutting angle and we have to face this. This is an attachment which helps in grinding these two faces of the drill. Now first of all we have to set at an angle of 118^0.

Now here we have set it. Here it is showing 90 + 28 so it is 118^0 ;now at this angle we have to set this attachment. And here there is a graduated scale that we have set at an angle of 118^0meaning that if we now move in this way,in that case the face will be in touch with the grinding wheel.

Because it is set at (90 + 28), so it is $118^0$and in that case it will be just ground like this. Now for the other face we have to just rotate the drill in this attachment itself and the other face can be ground, so now we will show you how we will switch on the machine and we will show you how these two faces are ground. Now you can see that the face of the drill is getting in contact with the grinding wheel.

And the face will be ground; this attachment as it is is set at an angle of 118^0, so that is the cutting angle of the drill and now that face has been ground, so next for the another face we have to rotate the tool as you can see this it is being rotated and the other face is ready for being ground and that face is now in touch with the grinding wheel and the other face is now being ground.

This grinding wheel is a special grinding wheel because you can see that the face of that grinding wheel is actually grinding the drill it is not outer surface but it is the face of the grinding wheel. This is a cup type grinding wheel which is used for grinding the drill. Now in the same machine you can see that the grinding wheel has been changed earlier, if it was a cup type grinding wheel which was used for grinding the tool.

Side rake of the tool and then the face of the drill, but here we have changed the wheel to the wheel which is capable of doing the surface grinding. Surface grinding, as you know, is making a flat surface. Here is the wheel which is used for the surface grinding. This is the workpiece and this workpiece will be ground, surface grinding of this surface will be made and this is a ferromagnetic material. The workpiece is mounted on a plate which has a magnet.

This can be demagnetized or magnetized depending on the handle position; there is a handle. This handle will make this magnetic or nonmagnetic. When the clamping has to be done, this workpiece will be clamped very rigidly and afterwards the entire set-up is mounted on the bed of this grinding machine. This is the clamp.

And here depending on this thickness, the clamp height can be changed because it has the rack cut on this, as well as on the other face which is mating with this. This clamp we have shown earlier, when we were showing you the tools and the fixtures, both of them are here and on the other side there is another clamp and the mechanism is the same, and you can see that this entire setup that is the magnetic clamp.

This is mounted on this bed with these two clamps, now this is ready for grinding. This is the axis of the grinding wheel, this is the arbor and on this at the end of the arbor the grinding wheel is mounted and you can see the mounting of the grinding wheel which is little different than the one that you have seen for the grinding of the drill or the grinding of the turning tool. Now when this machine will be on, it will be demonstrated to you.

And then you will see that this will rotate and the table reciprocates. Now the reciprocation will be shown to you manually, so that it could be visible in a better way for you. But otherwise, this is done hydraulically there is an end switch and this end switch makes that reciprocation possible.

Mr. Srinivasalu will demonstrate how this surface grinding process can be accomplished. The machine is on, as you can see the grinding wheel is rotating at a very high speed and I told you that the speed of the grinding wheel is about 10 to 80 meter per second. It rotates at a very high speed, the feed is given which is by rotating the handle as you can see that and the surface is being ground. This is the reciprocation that I was telling you that the table along with the workpiece is reciprocated.

And the entire surface is getting ground. To get the entire width ground you have to have the feed in the Y direction that means in the feed direction, that is, along the longitudinal direction you are having the reciprocation and in the cross feed that is perpendicular to the longitudinal feed and you have to have the feed to get the entire width covered. So, pass by pass the entire surface will be ground.

In each pass, one segment of the width is being ground and when the cross feed is given finally, the entire width and the entire surface will be ground. You can see that it is rigidly mounted on the magnetic plate this is how the plates or the workpieces are mounted during the surface grinding. I would like to demonstrate another mechanism which you can see here. This is the gear box in the cutout where you can see how a gear box in a car, in a vehicle works and how the gears are changed.

This is the handle, now this handle is in the neutral position. This shaft is the input shaft and this is the output shaft, meaning from here the transmission goes to the wheels. At this moment it is in the neutral position. If you rotate this you can see that the output shaft is not rotating because it is in neutral.

This is the clutch and this clutch is in the disengaged position. If you rotate this input shaft and you know that the input shaft is rotated by the engine and that engine is the internal combustion engine, I am talking about the vehicle it may be a car, it may be bus, it may be truck. That internal combustion engine supplies the power to the input shaft and this shaft is connected to the output shaft of the internal combustion engine.

Then when you are changing the gear, at this moment as I said this is in the neutral position so this is disengaged with the motor output shaft is disengaged with the motor. Now here there is gear train as you can see that this gear is meshing with another gear then the transmission goes to the intermediate shaft and from here this gear goes into this; these are the spur gears, these are the helical gears and you can see that this is the bigger one, this is the smaller one.

Depending on which gear is meshing with which one, you will get the transmission ratio; for example, if your input shaft is rotating and you want a higher rotation to the output shaft, like in fourth gear or fifth gear of a car, in that case the transmission has to be from the bigger gear to the smaller one.

And vice versa when you need to have the smaller RPM, for example in the first gear and the second gear. In the first gear and second gear, the input shaft has smaller gear, by smaller gear I mean to say the number of teeth will be less and similarly, the diameter will be less.

So, if a gear with less number of teeth transmits power to the gear with the larger number of teeth in that case the RPM of the output shaft will be less than the RPM of the input shaft, because the transmission ratio is accordingly made. This is $\left(\frac{N_1}{N_2}\right)$ which is less. Now, in the first and second gear you have to have a larger torque. So, as the RPM is less, the torque will be higher.

And as the gear is changed, meaning that as you are transmitting from a bigger gear to the lower gear, the RPM will be more and the torque transmitted will be less. So, at the lower gear when the car is just starting you have to overcome the friction between the tire and the road and the car is very heavy, so the friction force is very high. You have to overcome that and because of that you need to have a very high torque but your RPM or the speed should be low.

But as you go, as the car has started going it has already has the inertia. You do not need the higher torque than the first and the second gear and you will have the less torque carrying capacity to the output shaft with respect to the input shaft and your RPM has to be more because at fourth gear and fifth gear the car speed is higher. Now let us say that you change the gear, some gear for example, we have changed here.

And as you can see that the transmission is going from the bigger gear to the lower gear. Bigger gear means more number of teeth to the less number of teeth. Therefore, the speed here is high as you can see the speed is higher the output shaft and so on. There are first gear, second gear, third gear up to fifth gear and there is a back gear as well. Mr. Aman is going to demonstrate how those gears are changed, you can see that the lever has different positions.

You take it in different positions you remember that in car it is 1, 2, 3, 4, 5, and the back gear. This is the first gear. First gear means a lot of torque is transmitted and RPM is not very high. In that case the smaller gear transmits the power to the bigger gear. You can see that now it is faster. This is second gear. Now the position is changed and this is the third gear. In third gear, the torque is relatively less and the RPM will be more.

In fourth gear torque is even less but the RPM is higher as I was telling and here if you see this is the back gear and in the back gear, this is input shaft is rotated in this way and you see this output shaft is rotating in this way. This is a back gear. This way the gear is changed with the help of this and then you can put it back to the neutral position and neutral position means with the rotation of that you can see that this is not rotating.

This is how in a compact way the gear drive or the transmission ratio is made in the gearbox of an automobile. This is also a gearbox, but here additionally kick-start mechanism is added. Scooter or two-wheeler which is lighter than the car, is normally kick started. There are 2 ways of starting that, these days of course there are electronic starter.

And along with that there is a starter which is kick starting. When you are kicking, you can see that this is rotating at a faster rate and then it starts, I mean the vehicle is getting started vehicle means here this is particularly for 3-wheeler, scooter, motorcycle. Such kind of gear boxes are there. This is smaller than the previous one which was used for vehicles. Here this is the kick start you can see that there is a mechanism.

And when you are kicking you can see that this is moving. This rotation is being imitated by this kicking mechanism and after that with inertia it can get started as it is done in case of motorcycle and scooter. Here you can see the differential mechanism of an automobile and you know what is differential mechanism. This is for the rear wheels where the transmission is given from the internal combustion engine.

Particularly when a vehicle takes a turn and in that case the velocity or the speed of one gear which is at the end of that road, the other side of the road is more than which is in the inner side and this is simply because when you are considering the speed of the outer wheel; there the radius is more and therefore, you know that the speed is given by πDN , D is the diameter and N is the RPM, RPM being the same because this is the internal combustion engine which is used and diameter is changing.

So, if the diameter is more, the speed will be more and when it is taking a turn like this in that case this outer part will have a bigger diameter and the inner will have a lot less diameter. Then the speed is changing. Now, when the speed is changing and the RPM being the same you have to have a mechanism, so that these two speeds are different that is why the mechanism is called the differential mechanism.

And you can see here in this mechanism, this is the input shaft from where the power is transmitted to the this is the axle of the rear wheel where the transmission goes in and as you rotate here from the input shaft through the spiral gear, it is connected to another spiral gear of the output shaft and this spiral gear of the output shaft is connected to other gears with the planetary drives.

There are four planetary gears and each of them has their own transmission ratio and this is given a different transmissions to the right wheel and the left wheel and therefore, as a result if it is rotating as the input shaft we can see that both of them are rotating in a normal case. But when it is taking a turn suppose this wheel has the less velocity, let it be 0 while taking a very abrupt turn. In that case as you can see that this is not rotating.

But still this is rotating because the input shaft is rotating at a constant speed. There is no change in the RPM or the speed of the input. This is the constant one. And now, in normal case once again when the input is given both the wheels are rotating.

If it is taking a turn to the left or to the right this is what will happen and this is done by the mechanism that I have shown it to you this is the differential mechanism that is why it is called the differential, because there is a difference in the speed between the two wheels and this is done by the planetary wheels and planetary wheelers are connected to the other wheel which is on the shaft of the other wheel.

So, the input shaft is connected to the spiral gear of the shaft of the output and then in its turn that spiral gear with the help of the planetary gear is connected to the other wheel, again shaft is the same, but on this output shaft there are two wheels. These two wheels are independently mounted with the help of this gear drive; so, that is why I am saying it is independently mounted in the sense that when this is rotating, this may not rotate because of that mechanism.

This is what we need when the car takes a right turn or the left turn. The wheel speeds have to be different and that differential in the speed is made possible by the differential mechanism which is used in automobiles let us say SUVs, trucks, buses and so on. Now we are going to demonstrate you the principles and the working of the computer numerically controlled machines. In this lab we have few turning and the milling computer numerically controlled machines.

I will like to remind you that computer numerically controlled machines are different from the conventional machine in the way that each axis in the computer numerically controlled machines that is the x, y and z each axis is individually driven that is one aspect; in the conventional machine what you have seen is a prime drive, one drive and that drive is transmitting the power to the output shaft and the feed is taken from there only.

So, there is only one drive for the entire machine. In these machines this power is given to the x, y and z individually. So that individually these axes can be driven, therefore, any kind of a configuration that you want with the help of a combination of the movement of along the x, y and z axis you can achieve.

In conventional machines, you can machine a particular part, let us say an example is the turning lathe, it is called a turning lathe because only the turning process can be performed. So, only certain parts can be made, for example, you cannot make parts that can be made on the milling machine; Bigger flat surfaces you cannot make or you cannot make a contour surface in the turning lathe.

This is the difference between the conventional machines and the NC numerically controlled or the CNC machines. CNC stands for Computer Numerical Control. NC stands for the numerical control machines. In the case of the CNC and the NC machines, since all the axes are individually driven, we can have any kind of a relative movement between the tool and the workpiece. As a result, various configurations of the parts can be made here.

Even make shaft for example, using the same machine, you can make a gear, you can make a flat surface and so on. Those are more flexible; to increase the flexibility of the machines of the conventional machines, these kind of machines are introduced and as I told you, it is roughly about 1952-54 when these machines have been evolved already, now, what we are going to show in these machines is that first we will go for the turning. This is the drawing for the part.

This I have already shown you through the Power Point presentation. We are going to make a part like this out of this blank, where we have the flat surfaces, tapered surfaces, thread, chamfer, groove and we have the semicircular or the radius of that particular side. Now in doing so we will be showing you what kind of movements the tool has to make.

For example, to make this length 65 out of a length which is more than that, you have to face it. The tool from the 0 position, it will go to certain point and then it will face it, so to remove the excess material from the blank as well as from this side. This is just an example of a very small movement of the tool. Similarly, you will have different kinds of movements like making the tapper surface.

To make the chamfer, to make the threads here if you see that there is a thread made, all these operations we are going to show you in the turning CNC and similarly for the turning, for the

CNC milling we are going to show how a part can be made and the entire procedure I have already described to you and here it will be shown to you how this can be made in a machine.

For milling, it is little different; as you see that there are semi-circular radius given, here it is the radius given, here it is the inclined surface, these are the straight surfaces and so on and how they can be programmed and what kind of symbols are used for the programming that will be shown to you and that will be demonstrated to you how this can be implemented.

Now, before we go to the machine, let me tell you that first the program is made having the drawing of a part that you have to make; having that we have to first make the program manually. When the program is made manually knowing the codes, knowing the symbols as it has been told to you, there are different kinds of codes from A to Z and each one symbolizes something, for example there are G codes, N codes, M codes and so on.

Further, A to Z all the 26 alphabets are used for making the program and each of them means something that I have already told to you. Similarly, there are digits from 0 to 9, there are points there are plus or minus signs and so on and each of them indicates something for example, if you have to change the feed, you have to symbolize that feed as F, if you have to change the speed, symbolize that with the help of a letter S which stands for the speed and so on.

Overall, each letter, each symbol means something. The machine has to understand this language or these codes. I will tell you how these codes can be generated and how it can be interfaced with the machine, how it can be put on the machine and how the machine can execute that. But before that we go to the machine we have to make sure that the program that we have made is flawless.

There are various parts, the parts can be very complicated. And for those complicated parts, the programming can be very complicated and a lot of lines in the program can appear. Each line has to be executed; now when you are making the program manually, flaw can occur; a point is missing somewhere, one sign is missing somewhere, some digits are missing. This has to be simulated to make sure that the programming is right.

For this purpose, there is a simulation software, we will show you how it can be simulated in the simulator, this program that you have made manually this has to be input and then each line has to be executed to see how this line is understood by the machine and how the machine is executing this line and the program. And finally, you can see that there will be a relative movement between the tool and the workpiece.

According to the program that we have made and the entire part is being machined. So that is one side of it when you are making the program manually and then putting the program in the machine. The programming can be made manually, that is one part of it, but then that program you are putting in the machine. Here there is a display if you see this machine, this is the EMCO concept MILL 250 this is the machine; here also you have a keyboard and there is a display.

So, the program that you have made on a piece of paper manually beforehand depending on the part that you have, this program can be input to the machine through the keyboard that the machine has, this is in-built keyboard. Using this in-built keyboard and each time you are pressing a key it will be displayed here and this way the programming can also be made and put it in the machine.

Then when your program is made, input is given here, after that when you are switching on, according to the program, there will be relative movement between the tool and the workpiece. But before doing that, make sure that the program is right and you run it in the simulator and the simulator is showing no conflict in the program and then only you bring that program and put it here and execute it.

Recently computer aided manufacturing is being used for making the program automatically. There is a special software used, for that we have a software which is ‘fusion’ and we will show you how that fusion software can be used to generate the program that you have made. For that, first of all you have to have the part drawing.

So that part drawing you have to make in the fusion using that fusion software. You are making that part and giving all the dimensions which will be required in that, like for example I have shown you here, this part is made with all the dimensions, according to these dimensions your program has to be made. Here we have made it manually as I narrated but then using the computer aided manufacturing, the same program can be generated by the fusion software.

You have to make this drawing in the fusion, according to that the software will understand what are the dimensions and how the tool should move. Then the software is capable of finding out the optimum way how the tool should be moved so that the entire part can be fabricated, after the drawing is made. From that drawing you can make the 3-D drawing also.

And from the coordinates, from the dimensions the program will be made, the code will be generated and the same code that you have made you have generated manually it will be generated by the fusion software. That code can be then electronically transmitted to the machine. In that case, you do not have to really touch the keyboard to make the program and input the program in the machine. That will be then electronically transmitted.

And according to that program, which has been made by the fusion software, the part will be made so in that case, of course your simulation is not required because the software itself making sure that the entire program which it is being made by the program by the software is right. Thank you for your attention.

(Video Ends: 01:00:10)