Production Technology: Theory and Practice
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Lecture - 24
Lab - 01

Hello and welcome to the course on manufacturing technology theory and practice. this is the lab part or the hands-on training through the online course. Initially we have given you the theory of the conventional machines, unconventional machines, numerically controlled machines and so on. Now in the laboratory we will give you an introduction to all these machines and the equipment that we have gone through in the lecture part.

We will demonstrate the equipment, demonstrate the tools, conventional metal cutting machines, unconventional machines we will not be demonstrating as such but we will demonstrate and show you the working principle of the numerically controlled machines. We will show you how to program as we have discussed in the theory part. Before we go to the lab, let me give you an introduction to the transmission to the manufacturing and the fabrication of the gears.

As well as an introduction to the tools that you can encounter in the lab and to the numerically controlled machines. How they can be operated and how the part programming can be made. first of all I would like to talk about the power transmission which is one of the most important aspects, one of the most important factors in any machine for that matter. In any machine the power has to be transmitted from the input to the output.

What do we mean by input is the input shaft which is connected to the main drive in case of automobile. Here we have the internal combustion engine and the input shaft or the driver shaft that is connected to the output shaft of the internal combustion engine with the help of the coupling and the power from the internal combustion engine is transmitted to the input shaft. From the input shaft this power has to go to the output shaft in a manner that there is minimum loss in the power.

And in case we have to increase the speed, decrease the speed, increase the torque, decrease the torque that we have to make it through the transmission in case of automobiles here we

have a gearbox or for that matter in the machine tool, we have a gearbox and through the gear train, we make the transmission of the power of the torque. And this transmission is not only through gear transmission, there are different kinds of transmissions and I will show you some of those transmissions in the slides.

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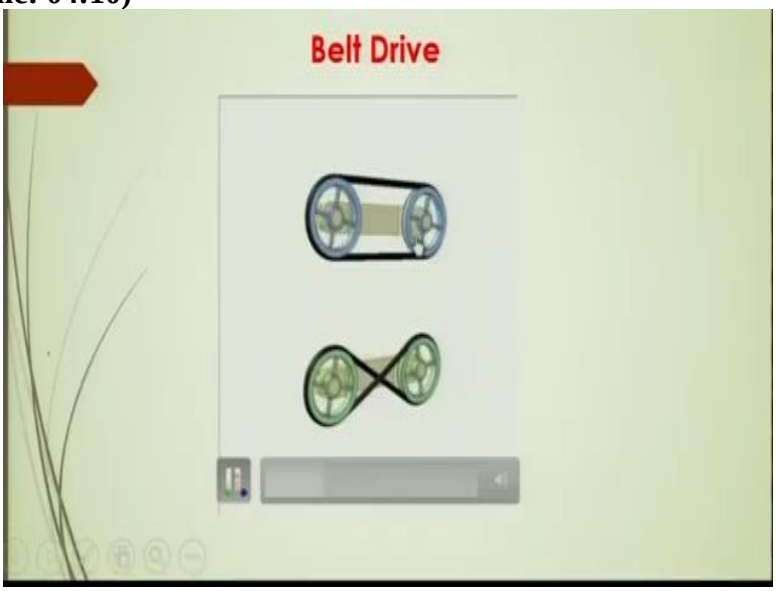

the power transmissions as you can see, first is the belt drive. As you can see here, in this belt drive, one of them is the input shaft, this is the input shaft; on the input shaft we have the pulley mounted and from here to the output shaft on which the pulley is mounted so the transmission will be from here to here. Let us see, how this can be made. as I told you that here is the belt drive.

As you can see that this is the input shaft on this input shaft, we have the pulley and to the output shaft, let us assume that this is the output shaft, on the output shaft we have another pulley mounted and the rotation of the power is transmitted from the input shaft here to the output shaft through this belt drive in this you can see that here is the same arrangement as the previous one, but in this case we have a cross belt.

The straight belt and the cross belt these are provided to transmit the power from the inputs shaft to outputs shaft but in the straight belt, the rotation of this pulley and this pulley will be in the same direction whereas, for the cross belt the rotation will be in different directions. Let us look at it, let us see how it can be done. As you can see the power is transmitted from this pulley to this pulley and they are rotating at the same direction because it is a straight belt here.

And in this case, here we have the cross belt in case of straight gear, as you can see that these 2 pulleys are rotating in the same direction. And in case of the cross belt, if this pulley is rotating in this direction, another pulley is rotating in the opposite direction. So that is why we have the straight belt and the cross belt. In the gear as you can see, that transmission is through a belt and the belt is sitting on a groove of this pulleys.

Here if the torque applied is very high, in that case there may be a possibility of a slip meaning that if the torque is very high, in that case if they are not capable of transmitting, then the belt will slip on the pulleys. Therefore, these are the transmissions which are not the positive drives. Here important thing is the transmission ratio.

If you see that both are rotating almost at the same speed, because the diameter of both of these pulleys is roughly the same. To have the more transmission ratio of the drive, in that case the diameter of this pulley if it is bigger and the diameter of the input shaft is small output shaft is smaller in that case, the output shaft will be rotating at a higher speed than the input shaft is rotating and vice versa.

When the driver gear will be of a smaller diameter of the pulley and the driven gear diameter is bigger, the transmission ratio is less. The transmission ratio is determined by the ratio of the diameters of these pulleys, input divided by output diameter.

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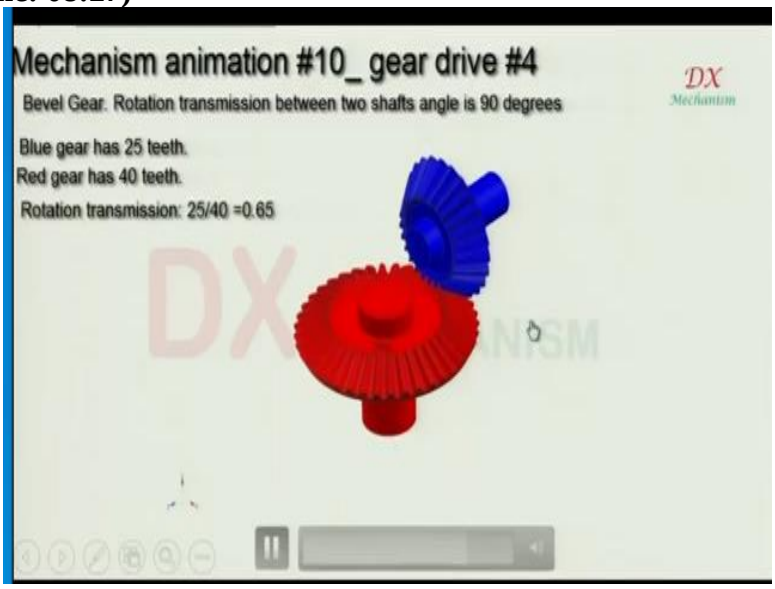

The next mechanism that is for transmitting the power through the gear drive. However, here you can see that the gears are bevel gears and these teeth of the bevel gear are cut at an angle, this is the input shaft on which the smaller gear is mounted and this is the output shaft where this red colour gear bevel gear is mounted. When we rotate them, as you can see that during the rotation this pulley which is this gear which is the input gear, this is transmitting the power to the output gear.

And here also the transmission ratio is given by the number of teeth of the input divided by the number of teeth of the output. Accordingly, if your input gear is smaller and the output gear is bigger, in this case this shaft will be rotating at a less RPM than the input shaft and vice versa. If this is bigger, this is smaller than it will be rotated at higher speed; this is the same thing as in case of the pulleys that we have seen in the earlier mechanism.

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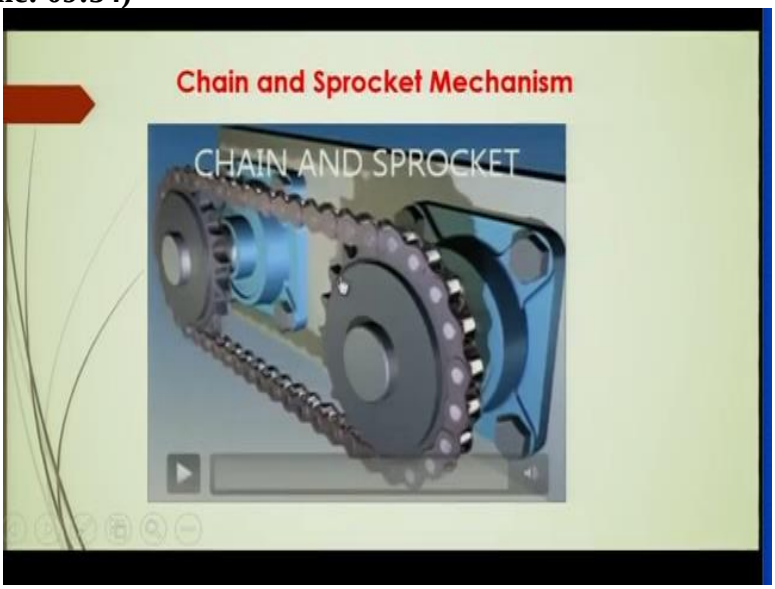

The next mechanism that you can see here is the chain and the sprocket mechanism which is similar to this belt drive mechanism only thing is that here the transmission is between the 2 sprockets or this is one sprocket, which is mounted on one shaft and this is another sprocket which is mounted on another shaft. This must be familiar to all of you because this is popularly used in the bicycle.

In the bicycle, you are pedalling and this in that case the pedal is connected to the shaft which will is considered to be the input shaft and the power that you are applying to the input shaft is transmitted to the output shaft through the chain. As you can see that the sprockets have the

teeth and those teeth are rigidly sitting on these slots of the chain and the transmission is made power is transmitted from the input to the output.

Why we call it a positive because in this case the slip between the sprocket and the chain is eliminated there cannot be any slip line in case of the belt drive as we have seen that there is a possibility of slipping the belt may slip over the pulleys. Here there is no possibility of slipping therefore, this kind of mechanism is called the positive mechanism. If we drive that you can that this is the input shaft and when it is driving so both the directions of rotation of the input sprocket and the output sprocket is the same.

Because it is like the straight belt that we have shown in the belt drive transmission and here these chains normally do not come as a cross chain like in case of the cross belt because of the you construction itself here it is almost not possible. Herethe transmission is made from the input shaft to the output shaft through the chain and the sprocket.

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This mechanism it is another mechanism for transmitting the power from the input to the output shaft through the Geneva mechanism which is one of the most popular mechanisms when you have to transmit the power continuously rotating input drive input shaft when it transmits power to the output shaft which should be rotated not continuously but intermittently.

As you can see here, this is the entire Geneva mechanism this is the Geneva wheel and this is the pin, pin is sitting on this disk and this disk rotates continuously and while rotating this pin

goes inside the slot of the Geneva wheel and comes out and during that moment as you can see there is one movement or one cycle one indexing of the Geneva wheel as you can see it is entering and coming out and in that case it is moving from here to here. So, it is an indexing when you need the output shaft to index.

The transmission is the continuous rotation of the input shaft this is the input shaft the pin comes in and goes out of the slot of the Geneva wheel in that case it is coming from one position to another position. This kind of mechanism can be used where we are having automatic assembly. The table on which the automatic assembly is made, that table has to index from one position to another position for positioning the sub assembly against the work head on which the operation will be performed.

When it is coming to one particular position, in that position, it needs some time for the operation to be finished. So, that time is the time when the pin is rotating from here to here from one slot to another slot. Then when it is entering into the slot and coming out during that time, the sub assembly on that plate which is driven by the Geneva mechanism will be rotated.

That plate will be rotated that is indexed from one position to another position and another sub-assembly coming to this particular position where the processing will be performed. In such kinds of movements the Geneva mechanism is very effective in transmitting the power. Here this is the input shaft on which the pin is mounted which is rotating continuously and, once again, while rotating continuously the pin goes into the slot and comes out when the Geneva wheel moves from one position to another position.

Let us assume that each of these positions is a position where the sub assembly is to be indexed and it has to stay for sometimes for the assembly operation to be performed. That is the time which is called the dual time in engineering which is a technical term. This is effectively can be done by Geneva mechanism. Here as you can see the mechanism, the negative points are that here the pin is taking the entire load.

Entire load I mean to say that this Geneva mechanism on this shaft, on the output shaft is located where you have a table and on that table you have the heavy sub assembly. Sub-

assemblies will be located directly at this position and here we will have the machine. Machines are not located on the Geneva wheel as it is but the sub-assembly has to be here.

So, the load of the sub assembly will be on this Geneva wheel and with this load this pin has to be able to move that much load from one position to another position. The pin is becoming in this case the weaker point, if the pin breaks in that case, the mechanism collapses and it cannot work. This is the first drawback of the Geneva mechanism.

The second drawback of the Geneva mechanism is the number of stopovers. Here in this we have the 1 2 3 4 5 6 so there are 6 positions here and this number is limited in case of the Geneva mechanism Otherwise, the entire Geneva will be very large. The number of stopovers is normally 8 that gives the restriction on the working of the Geneva mechanism if you need to have more than 8 or larger number of the stopovers in that case Geneva mechanism cannot be effectively used because the diameter of the Geneva wheel will be very large.

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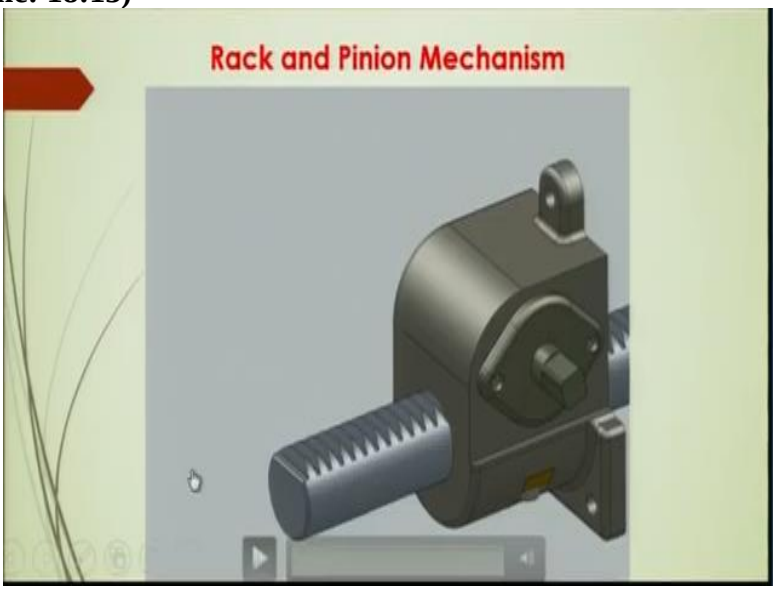

The next mechanism that we are going to see here this is the rack and pinion mechanism. This is the rack and we are going to show you in the lab how these rack teeth are ground or made and the pinion is inside. Let us start the mechanism and you can see the functioning and all the parts.

The pinion is positively in contact with the rack and if this is rotating as an input shaft, as an output shaft on which the rack this, that will be rotated. Here the rotation of the pinion is the

circular movement and the movement of the rack is the linear movement. So, here we are transferring the rotational movement to the linear movement.

This is an advantage here that this can be both ways that means if it is the input shaft is rotating clockwise then this will be moving from this side to this side and if it is moving to the anti-clockwise direction, the rack will move from here to here, to the other side. this is the advantage and since it is a positive drive because there are teeth in the pinion and the rack, therefore, here the torque carrying capacity of the rack and pinion will be more than in the case of the belt drive.

Belt drive, particularly for the flat belt, are used normally in case where the torque carrying capacity or the torque required to be transmitted is less, but in the case where the torque required to be transmitted is high, in that case the positive drive has to be used. In this case the rack and pinion drive can be used.

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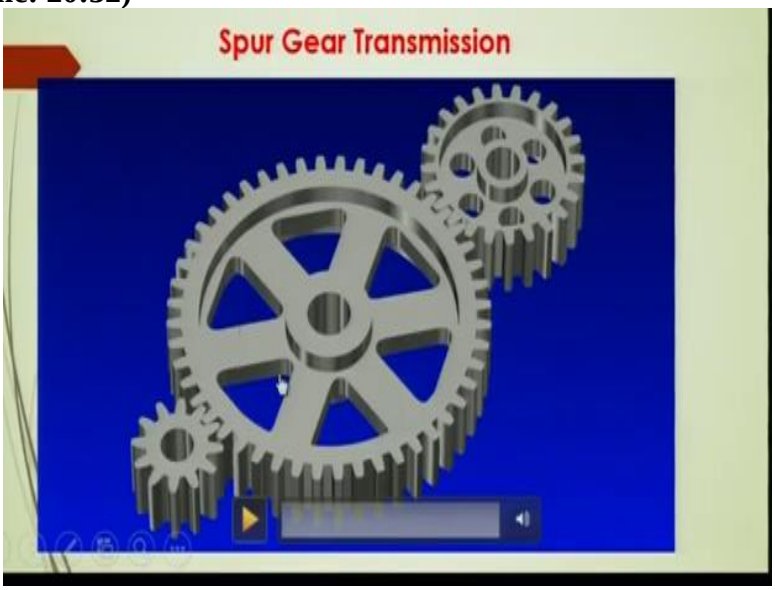

This is another mechanism. This is the gear train. Here all the gears are spur gears, there are 3 shafts one can be considered to be as the input shaft and this shaft on which this gear is mounted can be considered as the output shaft. The transmission is made, the motion is transmitted, power is transmitted from the input shaft to the output shaft through an intermediate gear.

The intermediate gears are required for two reasons, particularly like here in this case if the distance between the input shaft and the output shaft is larger than the sum of the radius of

this gear and the radius of this gear. If it is more, in that case there is an intermediate gear which is required. Second reason why the intermediate gear is required is that when the direction of the rotation of the input and output shaft should be different. Let us start this and you will understand that.

Here as you can see that when this gear is rotating in this direction the same direction this gear is rotating. This is because of the intermediate gear because when the input shaft is rotating in this direction, in the anti-clockwise direction, in the clockwise direction the intermediate gear will be rotating and then in its turn the intermediate gear is a couple with the output gear which will rotate the output gear in the opposite direction. This is in difference with what we have seen in the case of the belt drive.

Here, the direction of rotation of the input gear and the output gear is the same and if that is the requirement in that case, we have to have an intermediate gear as you can see here.

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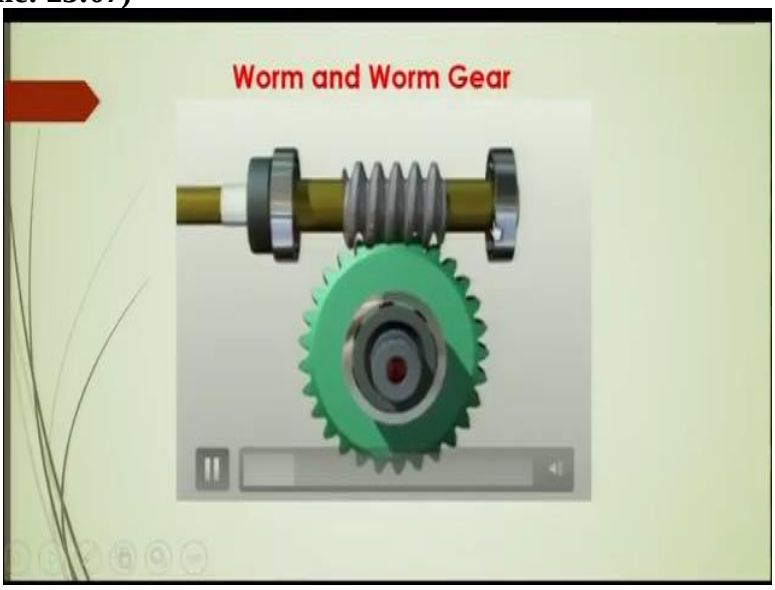

The next is the worm and worm gear; this is very effective in two ways, one is that here the transmission ratio can be up to 1 is to 40. You can change the rotation and the difference in rotation between the input and output shaft can be up to 40 times. And this is very highly unlikely that you can get this kind of transmissions ratio in case of gear transmission ratio or the belt drive.

Here this is the worm and the worm, it is so called because of the kind of spiral, kind of spiral teeth that the shaft is having. This is the worm and this is connected with the worm gear, it is

coupled with the worm. This is the worm gear where you have a kind of a semi-circular shape of the teeth, it is not exactly the straight teeth.

These are the shafts. Both of these shafts will be mounted on the bearings and the bearings will be mounted on the housing, this is the housing for the worm and this is the housing for the worm gear. The entire assembly is worm and worm gear mechanism. Here you can see the level of oil and it has to be dipped into the oil because of the high torque which is being transmitted, that creates high temperature.

This is the input drive that drives the worm which is on that shaft and that will in its turn drive the worm gear and on this shaft at the output we can have a pinion here or the sprocket and the chain and this will rotate then another shaft and that will be the ultimate output shaft; here we have the output shaft. In case of worm and worm gear only the worm can be considered to be as the input shaft and worm gear is the output shaft but from the worm gear another transmission is taken through the chain drive.

And then finally, the output shaft which is mounted on the output sprocket that can be considered as output shaft. In this case the basic advantage of the worm and worm gear I said that this can be 1 is to 40 transmission ratios. And another advantage of the worm and worm gear is that it has a self-locking, in the same way that if you rotate the worm, the worm gear will be rotated, but as we have seen in all other cases that in all other cases when the output shaft is rotated, the input shaft can also be rotated.

So, input shaft and output shaft can be interchanged if it is required in the sense that what you are calling as the input shaft,here in the gear transmission we considered this is to be input shaft, but this can also be considered as an input shaft meaning that you make the prime mover drive this gear and then from this gear you take the output transmission or the output torque.

But in case of the worm and worm gear, this is not possible meaning that only the transmission can be from the worm to the worm gear, but you cannot rotate the worm gear and then the worm will not rotate; if you rotate the worm gear shaft then the shaft or the shaft with the worm will not be rotated. This has a certain advantage. Let us think of a crane that can lift very heavy weight.

When it is lifting the weight and in case the power fails, if you use the gear transmission for lifting that, in that case the entire load can fall. In those cases, it is very important that if the power fails suppose the electricity goes off or for any reason the whole thing is jammed in that case the load should not fall it should stay there. In this case that is what it will happen that if the input is the worm.

So, you are rotating the worm and the worm gear is rotating, but if you stop rotating that then the worm gear will stop rotatating and will not rotate in the reverse direction as it would be the case with gear drive, for example.

This is self-locking, this also you can see in many in the pulling doors that if you pull the door from the top so at any level it can actually stay it will not go back if you leave it. These are driven by the worm and worm gear, or where you need the very high torque to be transmitted. These are basically the transmissions that I wanted to tell you and through these mechanisms mostly in mechanical engineering you will see that the transmission is made, the power is transmitted from the input shaft to the output shaft.

Once again, we have shown you the belt and pulley then with the cross belt, then we had the chain and sprocket mechanism. I have shown you the gear train, gear mechanism, we have seen the Geneva mechanism and finally we have seen the worm and worm gear. When we will go to the lab, I will once again show you how these mechanisms are used in different kind of machines.

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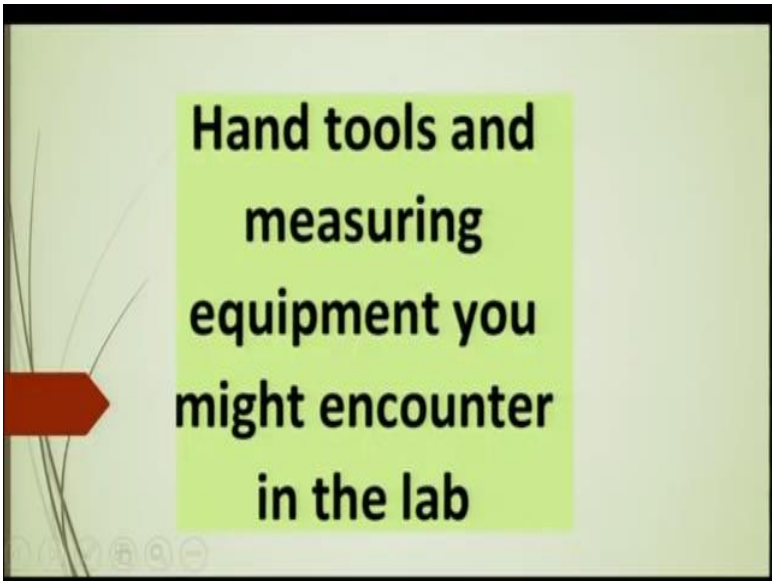

In the next slide you can see that hand tools and measuring equipment you might encounter in the lab when will go. Those instruments, we will show it to you we will describe each of these instruments, how they work and in which cases they are utilized. I will show you one by one.

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Here what you see is the bench vice. Most of you must be familiar with all of these equipment. All these equipment which are shown here in this slide, these are used in the fitting shop. Here is the vice; this is called the bench vice because it can be fitted in a bench on this table, in this particular case and in that case this jaw is fixed and this jaw can be moved on the lead screw that is here in the middle and those two are the supports.

If you rotate the handle here, by rotating this handle you are rotating the lead screw and this will be working as a screw as a knob and this knob which is the jaw this will be closer to the

other jaw. And in between you can fix the part; this is a workpiece, square workpiece round shaped workpiece, whichever workpiece you need to file or drill a hole or cut.

So, you can see these kinds of bench vices are used in many places even outside you can see on the road, workers are working on this. These are very handy and very effective in clamping the workpiece in a certain position. Here you can see that this is a hand vice, so this is hand held, the purpose is the same that is to clamp a workpiece or a part in between the jaws. Here you can see the jaws are like this. You can rotate this handle this is the lead screw in this case, this is the support and these are the jaws.

These jaws will be moving and one will be the fixed jaw like in this case and between the fixed jaw and the moving jaws the part will be clamped. This is the pipe vice, pipe vice is also very popular you can see on the roads where the workers are cutting the pipes or making thread on the pipes they have to be mounted in the vice so that there is no movement of this with respect to the tool that you are using.

Here also there is a lead screw, this is the housing of the vice, this is fixed bed and this is movable, this is rigidly attached at the end of this lead screw. On the other end the lead screw has an this handle using which you can rotate the lead screw. Here inside this threaded hole, through the threaded hole this lead screw is rotated and this jaw will go up and down and within this space the then there is a an attachment for the pipe.

These two attachments are rigidly fixed with the base and with the movable jaw and within this fixture the pipe will be fixed, pipe will be clamped by rotating this handle and the pipe can be cut or the thread can be made on this pipe. Here you can see there is a series of files and those files are required to file the surface that is to remove the excess material and the material removal rate is smaller and in some cases to increase the surface finish to make the surface finish better.

Here you can see that this is a hand file, this is a flat file this is a half round file, this is a round file, square file, 3 square files. By the name you can find out that a hand file is normal file which you can see that you use for flattening or for filing the flat surfaces mostly we will show you in the lab how the filing can be made properly, here this a flat file and hand file more or less their purpose is more or less the equal.

This is a half round file. So half round file will have the purpose of flat surface as well as the round shaped holes or slots, round files are exclusively used for filing the inside of the hole. And here you can see all these are given in a sectional view, the hand file sectional view will be like this if you make a section along this, this section will be like this, flat file section is here, half round file section is like this.

This is the round file as I said that round files are normally used for filing of the internal hole. Here is a square file. This is the cross section and this is the 3 square file that means here that is called the 3 squares these are triangular actually shape. And it has certain purpose of filing the square holes where you have the edge and this edge will be coincided with this edge here and they are the 3 square files are used here you can see the file card.

This is the wooden file and on that wooden file different types of files can be mounted since it is on the wood so it can be removed and another type of card can be mounted here this is the hacksaw. Hacksaw is this is this entire thing is the handle and this is the saw which is mounted between these screws this can be removed and if the saw is broken or the saw is worn out another saw can be mounted here.

These are the hexes; these are normally mounted here, this is one hole that goes in here and then another hole on the other side will go in here and it can be tightened. This is the normal hammer so that you can see.

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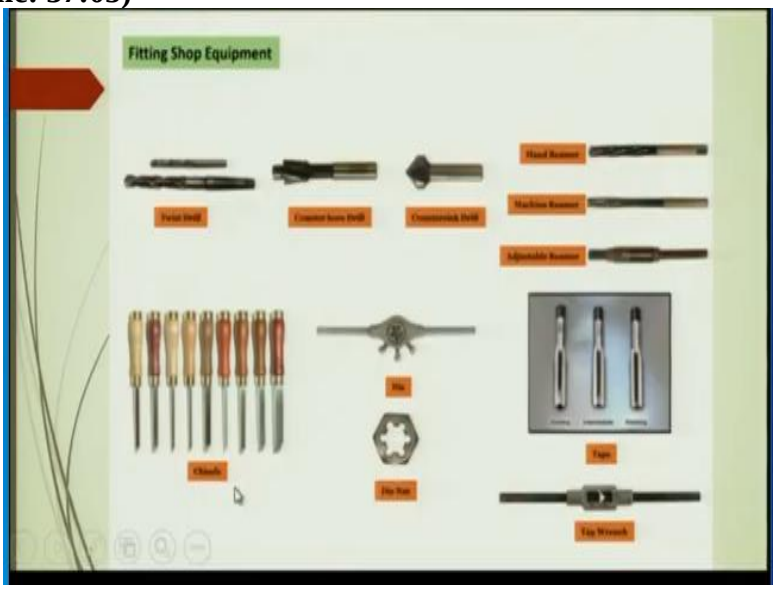

Other instruments or tools are twist drill. There are two different drills as shown here, one with diameter less than the other, both are twist drills. In this case you can see this is the portion which will be used to drill and as you know,the drill is used to make a hole, to drill a hole in a metal surface.

This drill has to be mounted on a chuck or drill holder, so this is the shank which is used to mount the drill in the drill holder or the drill chuck. In this case you can see that this is the cylindrical shank. And in this case for this drill where the diameter is more than the previous one this taper is the Morse taper and this holder for this kind of a drill will also have an internal hole which will have a tapered hole and that internal taper will also have a Morse taper.

So that when this drill goes in the internal taper of the Morse taper of the drill holder, it holds this drill through the Morse taper external taper that the drill has. There is nothing else in between this shank and the holder, there is no screw which needs to be tightened which needs to be used for tightening. So, it is that torque when it will be transmitted from the chuck to the drill, it will be only through the friction between the Morse taper.

That is the external taper of the drill and the internal taper of the drill holder or the drill chuck. In this case since the torque carrying capacity of this drill is less because the diameter of the drill is less, so, the hole that will be drilled will not be of larger diameter this will be of this diameter. The torque which has to be applied on this for drilling the hole will not be so high. Therefore, the shank is made as a cylindrical shank and that shank can be mounted on the holder not through the Morse taper.

But through some other mechanism which is applied on the cylindrical shank. In particular normally there is a groove and there is a spring-loaded ball. That spring-loaded ball will be just fixed in the internal groove and this spring-loaded hole and the hole which is made in the tool holder. This is just a snap fit, I mean the snapping the tool, the drill into the tool holder.

Here you can see the counterbore drill, counterbore drill is the drilling of 2 different diameters of the hole. Here you can see the diameter of the drill is different than the diameter of the drill here. This entire drill when it is driven to the workpiece there are 2 diameters, will be drilled together and the diameters of these 2 holes will be different. Two holes of different

diameters which are the counterbore drill, countersink drill this is as per the configuration of the drill, the drill hole configuration will be the same.

Countersinking is required when you have a particular counter sunk head of a bolt that has to sit in the threaded hole. So, you make the hole with the help of a countersink drill and then you tap that drill that means you make a thread so that within the threaded hole, the counters sunk bolts can go; there are particular types of counter sink bolts. That we will show you in the laboratory when we will go, what kind of screws are there which are sitting in the counter sunk holes.

Here you can see that this is a hand reamer, this is a machine reamer and this is an adjustable reamer. The reamer, first of all, is used to after drilling the hole some burrs will be there, will be some surface roughness so to mostly to increase the surface finish the reaming process is performed where the reamer as a tool is used particularly not to remove the material as such, but to increase the surface finish, for making the surface finish better of an internal hole.

These reamers can be of different kinds, this is the hand reamer where the reaming of the hole after it is drilled has to be made by hand that means there will be holder, again you can see the holder here that is called the tap wrench, in the tap wrench you can actually put the hand reamer and at the end of the hand reamer here there is a square cross section.

This square cross section part which is at the end of the hand reamer it will come in here fit in here and then with the help of this tap wrench , where the hand reamer will be put here and the bar will be held here that can be used for reaming the hole by hand. These are also used to hold the taps, I will come to the taps, in the taps also you have the square cross section at the end of the tap and this part will be held here in the tap wrench.

And then using these handles by manually you can make an internal thread with the taps. These taps are of different types; this is the starting tap, this is the intermediate tap, this is the finishing tap. Now the tapping as I said is made to make the thread in the internal hole so first you drill the hole. Then you ream the hole to remove the burrs and to make the surface finish better.

Then you use the starting tap when you were making the thread in a roughing process that is the surface finish is not very good then you are using an intermediate one. You are increasing the internal diameter of the thread a little more, material will be removed, but it is still not the final thread that is not with the complete surface finish which is required. For that you need to have the finishing tap and all these processes, how these 3 taps are used in a different way we will demonstrate.

Demonstrate in the lab and you will see that how the holes can be tapped, that is, how the internal thread can be made with the help of the taps. Here you understand that similar to the hand reamer the machine reamer are also used to ream the hole or for the reaming process of the hole with the help of the machine and those machines will be drilling machines, because in the drilling machine the spindle rotates where the drill is fitted.

And to drill the hole when the rotation and the thrust force both are imparted to the drill and instead of drill if you put the reamer, machine reamer, in the drilling spindle, in that case the drilled hole can be reamed that means further better surface finish can be obtained. This is the adjustable reamer where you can adjust the height of the reamer the length of the reamer, but purpose is the same this is also used mostly as a machine reamer.

Here you can see the die. This die is used to make the external thread. So, these are the taps which are used for making the internal thread and the dies are used to make the external thread. Here you can see the chisels which are mostly used in case of the wood when you are processing wood.

In some when you want to cut small thin sheet of aluminium or a thin sheet of metal, thin mild steel sheetthen in that case the chisel can be used apart from using it mostly in case of the wood. You can see the chisels being used by the carpenters, those who deal with the wood works.

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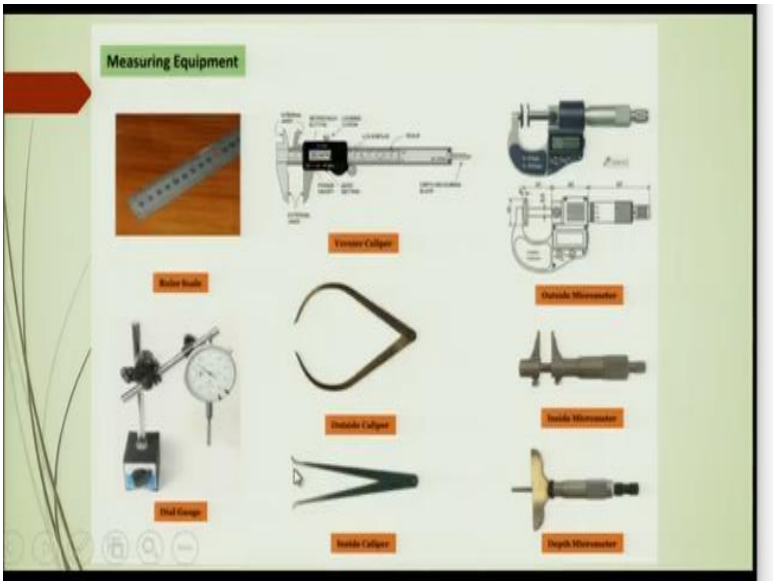

Next you can see the measuring instruments. This is the ruler scale, here you can see the vernier caliper. Vernier caliper is a precise instrument to measure the diameter of a cylinder or the external diameter of the cylinder or the internal diameter of the hole. External diameter can be measured by these jaws and internal diameter can be measured by these jaws and this is the scale.

Here we have a linear main scale which I will show you when we will have the metrology lecture series, I will show you how the least count of a vernier can be found out. In that case, I will show you both the scales, the main scale, use of the main scale and the vernier scale to find out very precisely up to 2 to 3 decimal levels. How to accurately find out the diameter?

Either it is an external diameter or it is an internal diameter; it is not only the diameter if you have a square if you have a cube, so to measure the distance between the 2 faces, you can also use the vernier caliper, in the lab you will see how the vernier caliper can be used similar to that for measuring the outside diameter.

We can use the micrometre and here you can see in the micrometre, the display is digital. In that case you do not have to read the main scale and the vernier scale and find out accurately what is the measurement, but in this case, the measurement can be seen in the display of the micrometres. This is called the outside micrometre because the outside diameter can be found out.

All the descriptions are given here, even the dimensions are given here you can see that this is the normal micrometre which is used in the metrology lab or the machine tool lab. We will see this here we have the inside micrometre, this is outside micrometre because as I said that outside diameter can be measured; this is the inside micrometre where like in the case of the vernier caliper with these jaws, here the inside diameter can be measured with the help of these 2 jaws.

This jaw is the fixed jaw in this case and this jaw is movable jaw this can be moved with the help of this screw. There is a main scale and there is a vernier scale circular scale with the help of that these scales you can find out what is the internal diameter of the hole. This is the depth micrometre, here this rod can be moved up and down with the help of the screw and this will be at the base.

And the distance between this base and this point which will be movable, the distance will show in this scale and you can find out the height for example for a cube. If you want to find out the height in this, you can find out with the help of the height micrometre or sometimes it is also called the height gauge. This is the dial indicator, dial gauge and you must be familiar with such kind of dial gauges you must have used it.

Here we have a base which can be mounted on a plate which is the metallic plate ferromagnetic material plate and there you have a magnet. You can activate the magnet and deactivate the magnet depending on that this base will be sitting rigidly or loosely and here you have a dial gauge. That dial gauge can be a fine dial gauge or a rough dial gauge. So that depends on what will be the least count what is the minimum distance between the 2 graduations in the dial indicator.

About the least count we will talk when we will discuss the metrology part. Here there is a stylus, this stylus is spring loaded and this stylus can go up and down; depending on that that the needle can move along the dial of the dial gauge and it will indicate the exact movement of this. This movement of the stylus is not much because these asperities are maybe a few millimetres only and this movement is highly amplified for the rotation of the needle.

So that little movement of the stylist can be felt by the needle and the needle will show exactly the measurement. This is called the outside caliper and that means first you find out

what is the distance between the 2 jaws, that is, what is the distance between the sides and then from there you can find out through the linear scale that what is the distance. And this is the inside caliper which will measure the diameter of the inside hole and here there is no scale directly cannot find out.

First this inside caliper measures the internal diameter and then you take that and find out from the scale what is the value. Here these are simple gauges by which you can find out the diameters internal or external or the distance.

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Here you can find out measuring and marking equipment, these are the dividers like in the geometry box that you get there is a surface plate this is absolutely flat. This is the V block and the V block is used use to place the cylindrical parts so that the cylindrical part axis is reamer coaxial. If you put a cylinder here and if you rotate that cylinder in that case you can make sure that the rotation is always around the axis of the cylinder.

Here is the bevel protector, bevel protector is used for measuring the angle accurately and again depending on the least count of the bevel protector you can you can measure a smaller angle or a larger angle and so on. This is a scriber to scribe the part to mark, this is the wire gauge; it has different profiles with the different diameters from very, very small to very large.

You can see these holes so the wire is passed through one of these holes and can be fitted; that diameter is written here, that will be the diameter of that wire. Quickly to find out what is

the diameter of the wire, you put this here and find out what is the diameter; this is called the centre square. This is the centre square which is used to find out again the angle and the exact square this is movable this can be adjusted this we will show you in the laboratory.

This is the centre punch, so here you can punch it before you drill the hole so this is required because when you are drilling, the drill may not touch the centre exactly if it is not marked. So, to mark the centre of a particular hole or a particular place where you are going to drill you have to actually put a mark; here these are the universal marking surface gauge you can see that here it will be mounted on the plate, on a flatbed plate and this is the marker, scriber kind of thing.

This will scribe the surface, this is a ruler and this ruler will give you that what is the distance what is the height here you can see the combination set, the combination set is used for making different kinds of measurements, that is why it is called the combination, here you can see the striking tools and these are the hammers.

These are normal hammers, and these are very popularly used in the households also; this the angle plate, this angle plate will exactly tell you whether there is a 90^0 angle between the 2 faces of a particular prismatic jaw or square jaw and so on. These are the basic measuring equipment basic measuring devices, which are used in any lab, either it is in the machine tool lab or it is a metrology lab or it is the machining lab.

When you will go to the laboratory, we will show you different kinds of machines in the lab. There are conventional machines like turning lathes, there are milling machines, there are drilling machines that are shaping machines. And we will show you the grinding machine; also we will show you how each of these machines can be operated, how a part can be fabricated on these machines and what are the steps which are involved in this machine?

All these devices with measuring devices that I have shown it to you, the transmission mechanism or the power transmission devices that I have shown to you, these are all used in the laboratories and you will see those devices and those equipment in the laboratory when we will go there. Thank you. The rest of the material we will discuss in our next session.