Basics of Mechanical Engineering-2

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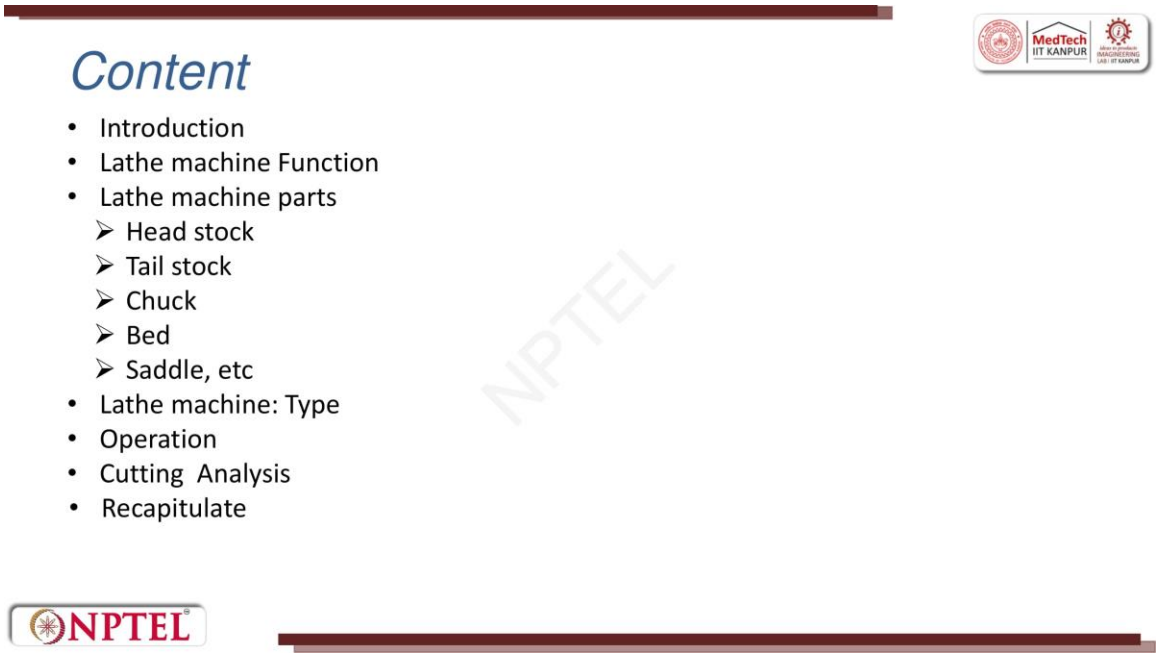
Week 09

Lecture 36

Basics of Machining (Part 4 of 7)

Welcome to the continuing lecture on Basics of Machining. In this lecture, we will primarily focus on a machine tool called the lathe. So, in this lecture, I will go in-depth and try to explain the machine tool side for a single-point cutting tool. And this idea you can extrapolate when we try to do multi-point cutting or abrasive cutting. 4

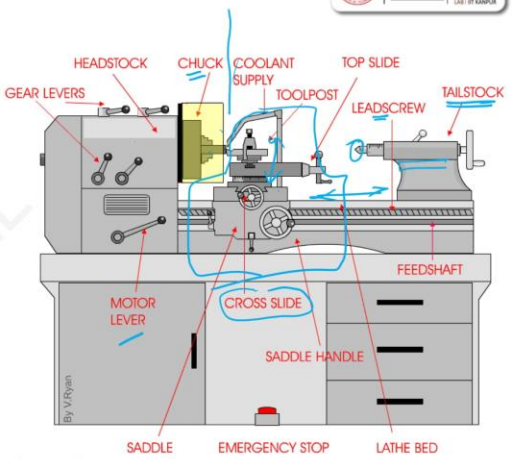


So, in the content of the lecture, we will have an introduction. Following that, we will cover the basic functions of lathe machines. And when we talk about a machine, the machine will have several subsystems. So, we will try to look into each of the subsystems like the headstock, tailstock, chuck, bed, saddle, etc. Then, we will try to look at various

types of lathe machines that have evolved over time. And then, some very simple operations that we generally perform with a lathe machine. And finally, we will try to recap this entire lecture.

Lathe Machine

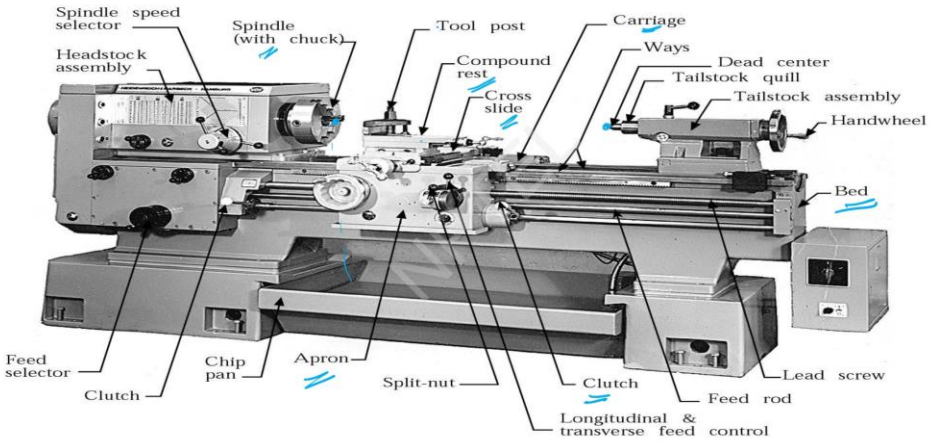
- A lathe machine is one of the most versatile and widely used machine tools in the manufacturing industry.
- It works by rotating a workpiece held in a chuck or between centers, while a cutting tool moves along the material to remove excess material and create the desired shape.
- The lathe's ability to execute a wide variety of operations, from simple shaping to complex machining tasks, makes it an essential tool in manufacturing processes.



motor → Gear box → Spindle ← w/p

https://technologystudent.com/equip1/mlathe1.htm

Lathe Machine



https://engineeringlearn.com/what-is-lathe-machine-types-of-lathe-machine-their-uses-complete-guide/

So, the lathe machine is one of the most versatile and widely used machine tools in the manufacturing industry. If you go to any industry, the first thing they will try to buy or

discuss is usually a lathe machine. I can say this was a basic machine. From here, several other machines were derived.

So, if you see a typical lathe machine, you will find a motor, this motor. So, here you will have a motor. This motor will provide the RPM. So, now you have to control or restrict the RPM. So, you will have a gearbox.

Now, this gearbox will maintain the speed, which will be attached to a spindle. So, in this spindle, you load your workpiece. If you see the entire story, it is here. So, you have a motor which is here. Then, you have a gear lever.

So, here there is a gearbox where you will have a combination of gears. Based upon the combination, you can achieve geometric progression in getting the speeds here. So, you have a gearbox. So, this gearbox is attached to a headstock. In the headstock, you will have a chuck.

In the chuck, you try to load the workpiece. So, this is one part of the story. The other part of the story is, suppose I have a long lengthier workpiece. workpiece, then there is a possibility when it rotates, it can wobble or it can deflect. It can go up and down like this. In order to avoid it, I hold the other end of the workpiece.

There comes the tail stock. The tail stock will be used to hold the workpiece when you have a long lengthy one. So, tail stock; you will have a tip which tries to get advanced by rotating the handle. There will be a rack and pinion or there can be a gear which tries to mesh. So, you try to advance the tail stock, it will go forward and it will try to lock, right?

The next important system is going to be the tool attached system. The tool attached system is the place where the tool is held. We saw in the previous lecture, the tool has a shank and a cutting edge. So, the shank is used for holding the tool. The tool can be advanced through rotating the handle here.

You can orient the tool in any direction of your choice, such that you can try to make a horizontal flat or a tapered shape with respect to the axis, depending upon their movement. So, you have two rods here: one is called the feed shaft, and the other one is called the lead screw. So, when we want to operate in automatic mode, we will try to use the feed shaft, and we also try to use the lead screw to get the combination where we try to control the feed rates. So, this talks about this linear motion, and you also try to have freedom in this motion. So, you rotate this handle to move in the x-direction if you want, or in the y-direction if you prefer.

So, you have this motion by the feed rod and lead screw. They both have independent roles. So, they are used to move the tool post. The tool post is sitting on the saddle. So, the saddle moves toward the spindle.

So, now let us see the names that are given. Motor lever, then you have the gearbox, headstock, wherein you have a chuck. The chuck holds the workpiece. Now, between the tool and the workpiece, there is going to be metal-to-metal contact, metal-to-polymer contact, or metal-to-ceramic contact. There is going to be friction.

There is going to be a rise in temperature. So, in order to avoid that rise in temperature, we use a coolant at the machining zone. So, there is a coolant supply pump. So, as I told you earlier, this is a tool post. Here in this machine, you have only a single tool.

You can also have multiple tools. For example, you can have a tool post which has a cuboidal structure where you can mount four tools. If you have a hexagon, you can have six tools. You can have, if you have an octagon, eight tools. So, all the tools will be loaded and kept on the tool post.

The tool post sits on a saddle. So, this is the saddle. So, the tool post sits on the saddle. So, the saddle is operated by the saddle handle. The cross slide, which I told you moves the tool in and out, is given by the cross slide.

Then, we have to understand the lead screw and feed shaft. The feed shaft, or they call it the feed rod. Then, we have the tailstock. So, by now, you will be able to understand all the parts that are there in a lathe machine, and there are some functions you can guess. It works by rotating.

This lathe machine rotates the workpiece held in a chuck or between centers. What are the centers? Headstock and tailstock between the centers. While a cutting tool moves along the material to remove excess material and create a desired shape. The cutting tool can move in this direction or perpendicular to the feed direction.

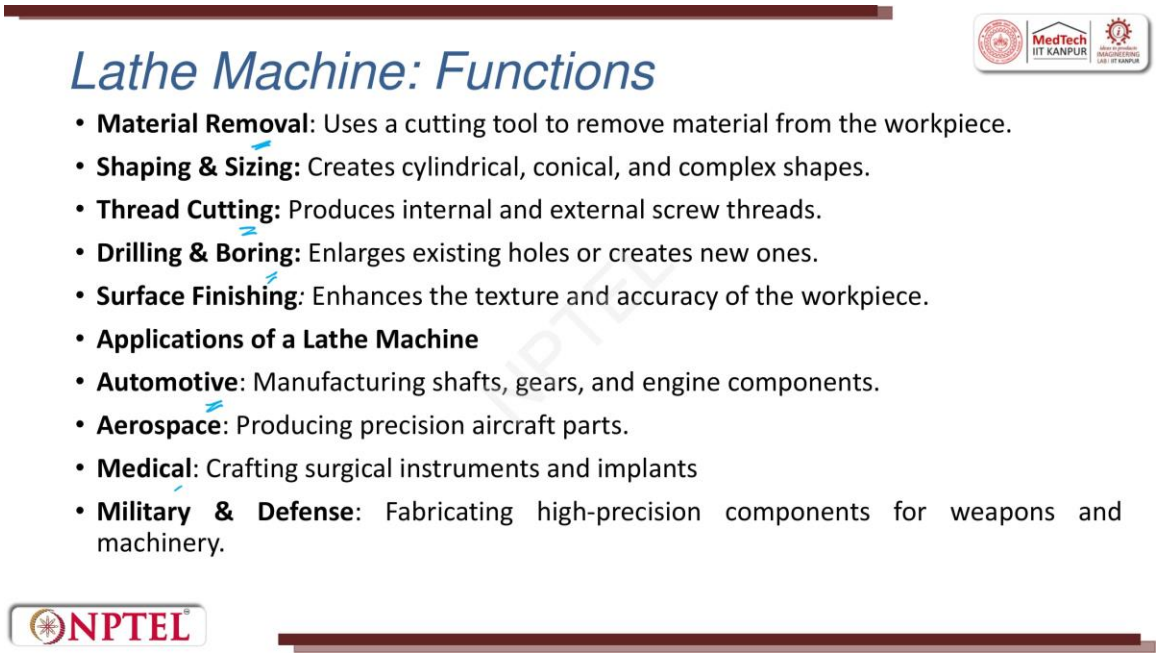
It can go like this, or it can go like this, or you can have a combination of this, then you get a taper. The lathe's ability is to execute a wide variety of operations, from simple shaping to complex machining tasks. If you can control both axes manually, you can try to make complex surfaces. Suppose you have to mass-produce it; then, this tailstock, the tool post, can be attached to a copy point or an engraving tool, which copies over the profile, and that is communicated to the tool post. So, correspondingly, you try to get the shape on the tool post.

The lathe's ability is to execute a wide variety of operation from simple shaping to complex shaping, makes it an essential tool in manufacturing. Lathe machine; if you have an axis symmetry part, if you want to do any geometry change, lathe machine is the fundamental machine which is used for. So, whatever we have discussed, I have put in a very detailed fashion spindle. Then, I said there is a tool post. Then, there is the tool post is resting on a compound slide.

So, this is again resting on a cross slide. So, this cross slide is sitting on a saddle. So, this is called as a saddle. They call it as a carriage. Then, I have talked about tail stock. the dead center, the live center.

So, the entire thing sits on a bed. So, when you wanted to have a automatic motion, then we try to use the engaging and disengaging. We also try to use a clutch for engaging and disengaging. So, this is the feed rod and this is the lead screw. They are used for automatic motion.

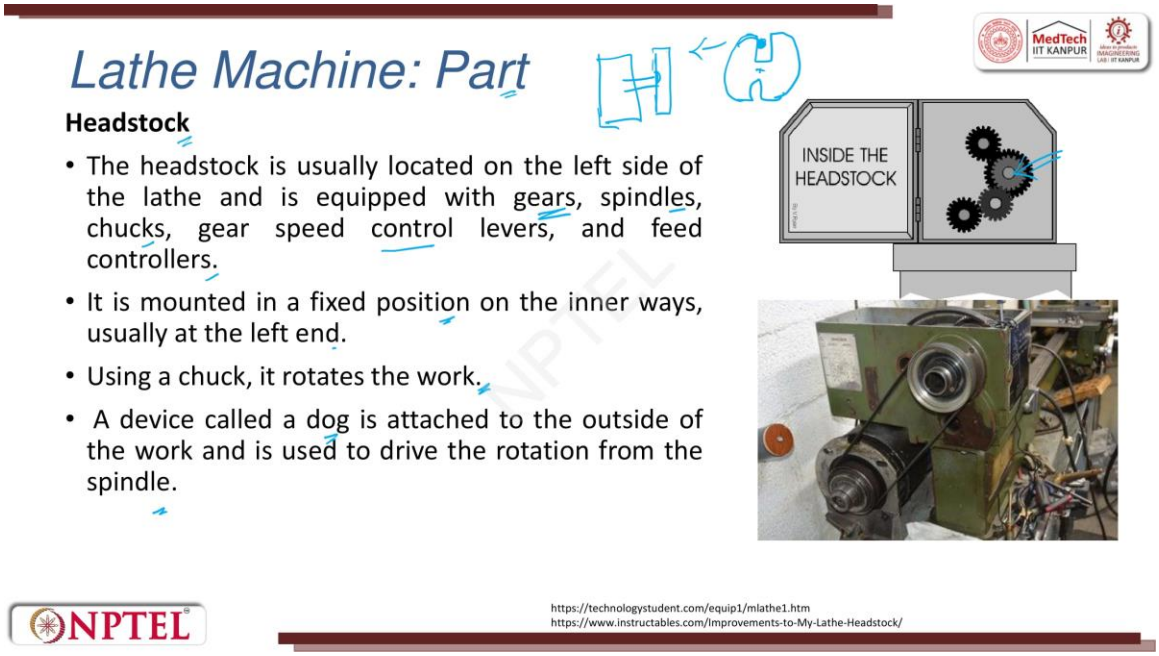
So, this machine has an apron which is also present. The tool, once it machines, the chip falls down and is collected in the tray, the chip selection tray.



So, some of the functions: material removal uses a cutting tool to remove material from the workpiece. Shaping and sizing create cylindrical, conical, and complex shapes. It can create shapes and sizes. Thread cutting is also possible.

Thread cutting will be explored in more detail—when to engage the feed rod and the lead screw. So, it produces both internal and external screw threads. Drilling and boring are possible. Super finishing enhances the texture and accuracy of the workpiece. And where are these lathe machines used?

They are extensively used in automotive applications, aerospace, medical, and military applications. Wherever precision axis-symmetric parts are needed, it is possible. So, let us look at each part in a little more detail.



Headstock. You see there are gear trains. So, the drive is given to this gear, and then subsequently you try to transfer the motion from this gear to the meshing gears. If the gear size is smaller, you will have higher speeds. If it is larger, you will have lower speeds. And if it is larger, the torque will be very high. So, torque is basically used when you give a larger depth of cut, we use a high torque.

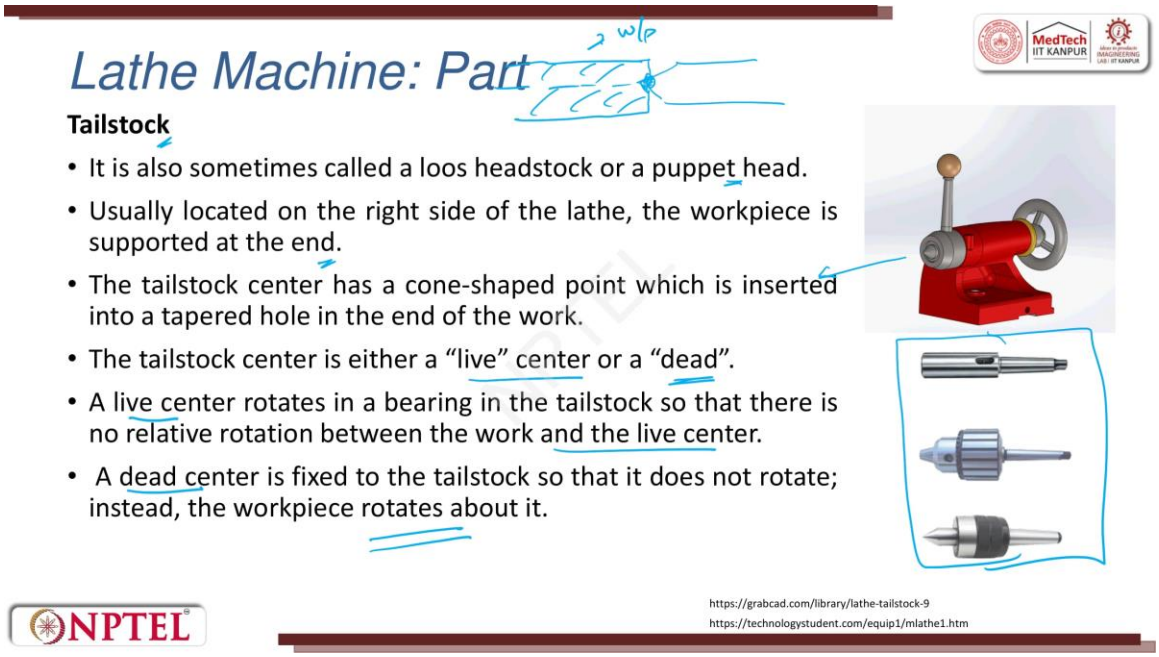
The headstock is usually located on the left side of the lathe and is equipped with gears. It can also have splines, chucks, gear speed control levers and feed controls. So, it is

mounted in a fixed position on the inner waste usually at the left hand side. Using a chuck, it rotates the work. So, that's where this gear train is attached to the spindle.

The device called a dog is attached to the outside of the work and is used to drive the rotation from the spindle. So, there are two types of workpiece loading. One type of workpiece loading is you directly mount it on the spindle. The other way what you do is you try to have spindle, then you try to attach a face plate. So, in the face plate when you look at the side view, you will have a slot like this.

So, in this slot, what will happen is you will try to attach it with a dog. So, this is called a dog. So, the dog—what it will do is hold the workpiece and lock it with the faceplate. So, here the workpiece is not mounted to the spindle; it is attached to a device called a dog. So, it is something like this: the dog is placed. So, when it rotates, the dog in turn is attached to the workpiece.

So, between centers, if you want to machine end-to-end, then we use this. The device called a dog is attached to the outside of the work and is used to drive the rotation of the spindle.



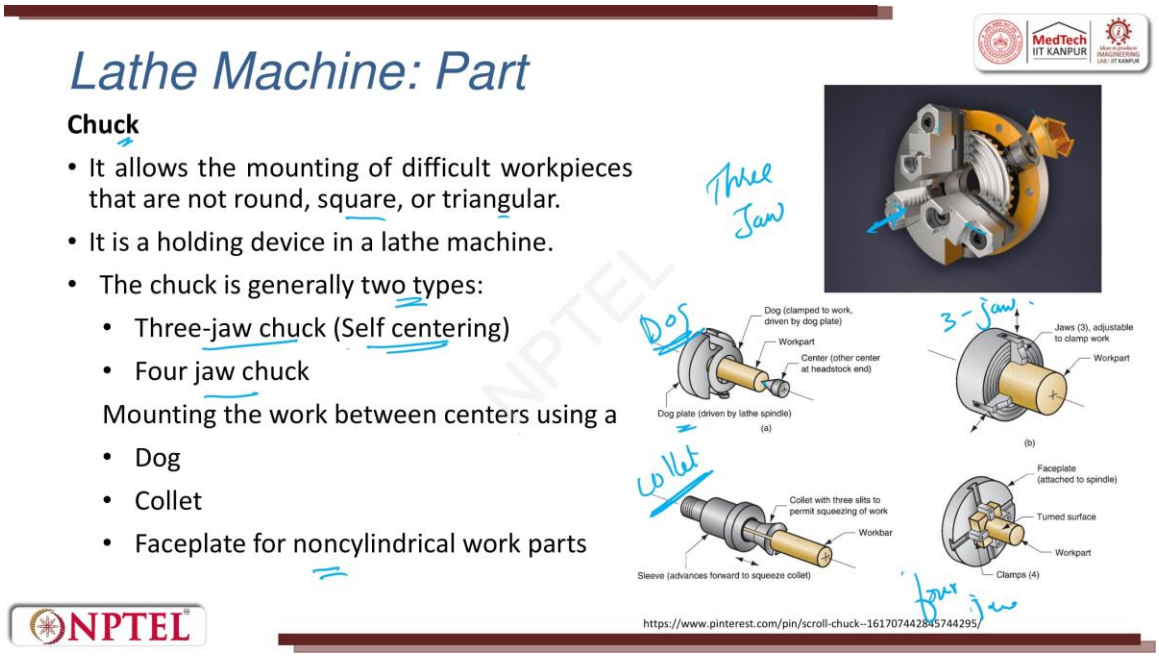
The tailstock is the other end, which we already saw. There is a handle that rotates, and then there is a rack. When you move it, this tries to advance the tailstock tip.

It is sometimes called a loose headstock or a pellet head, usually located on the right-hand side. The left-hand side is the headstock; the right-hand side is the tailstock. The workpiece is supported at the end. The tailstock center has a conical tip. Why does it have a conical tip?

It will have a conical tip. This tip is hardened and tries to locate the workpiece. So, this is the workpiece. So, the tailstock center has a conical tip point which is inserted into a tapered hole at the end of the workpiece. So, it is a friction contact and it tries to hold it.

The live center rotates in the bearing in the tailstock. The tailstock center is either called a live center or a dead center. A live center means where rotation is given. A dead center means no rotation is given. The live center rotates in a bearing in the tailstock so that there is no relative rotation between the workpiece and the live center.

A dead center is fixed to the tailstock so that it does not rotate. Instead, the workpiece rotates about itself. So, you have to understand the difference between a live center and a dead center in the tailstock. So, these are all things which you can remove, including this conical part. So, you can remove this conical part and fix these chucks.



So, here we will try to see a chuck. So, in a lathe machine, it is very interesting to see we have three jaws, and these three-jaw chucks are called self-centering chucks. So, that means when I keep the workpiece between the three jaws and rotate one jaw, all the jaws

will move uniformly and help in locking the workpiece. It is interesting. When you lock one, all three will come and grip the workpiece.

It allows the mounting of difficult workpieces that are not round, square, or even triangular. So, the three-jaw chuck we are trying to talk about is predominantly used for loading cylindrical parts. The moment you have a square or triangular non-symmetrical part, then you will try to use a four-jaw chuck. So, a four-jaw chuck is not a self-centering chuck. So, it holds the device.

The chucks are of two types. One is called a three-jaw, the other a four-jaw. A three-jaw chuck is called self-centering because when you try to rotate one of the jaws, it rotates the basic gear where on the face there are teeth. So, when you rotate this, this rotates. When this rotates, it tries to rotate every jaw.

And here you put a key in and then you rotate. So, this is a three-jaw chuck. It is a very interesting phenomenon. You should know it. So, three-jaw chuck and four-jaw chuck.

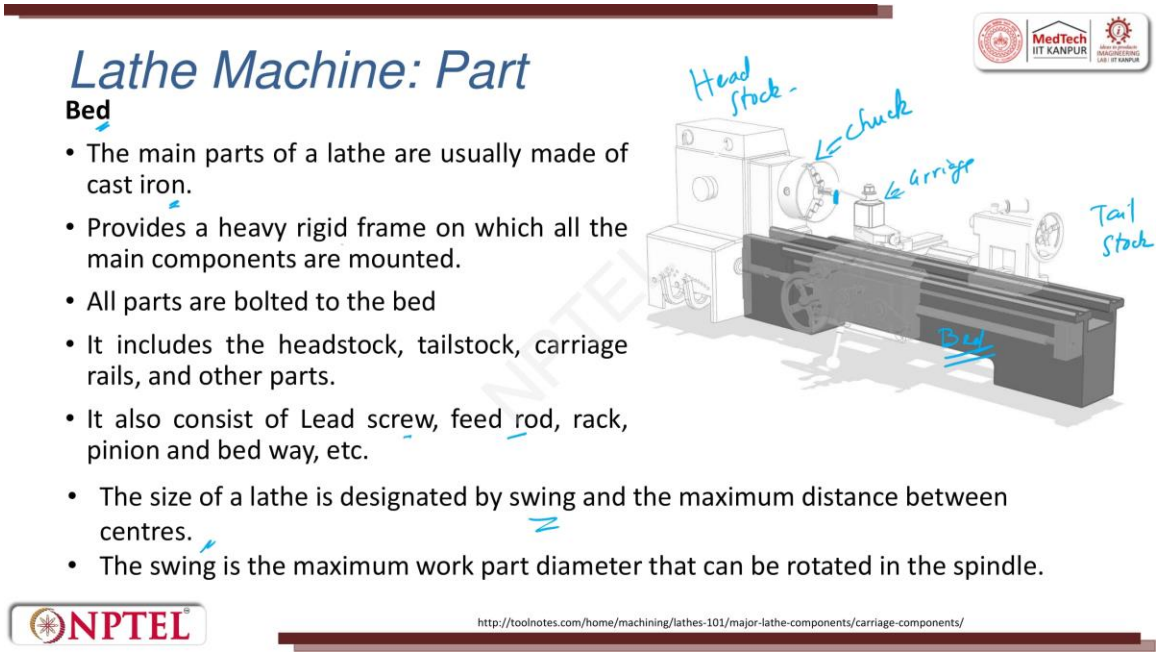
Mounting the workpiece between the centers uses a dog. So, this is called a dog, which I was trying to explain. So, the dog clamps the workpiece. So, this is a dog. This is a dog plate.

The workpiece is loaded, and here you have the dead center which comes in contact. The conical tip is touching the workpiece. So, this is a dog plate, which is used for mounting the workpiece. So, the next one is a three-jaw chuck, wherein the self-centering is done. You can also have a collet with three slits, which is also used to mount the workpiece.

So, this is dog, this is collet. Collet is, when you try to expand, you can push it from one side. It will have a reverse taper. So, it will try to hold it. Then, you can try to have a face plate for non-cylindrical part.

So, this is four jaw chuck. This is three jaw chuck. This is three jaw. This is four jaw. This is three jaw.

This is with dog and this is with collet. Collet will have something like an inverse taper and here the slits are made and the tool is stuck and when you pull it, it gets locked. So, it is very interesting. You should see all those things. There are videos. So, I would encourage you to look at videos to understand more in details.



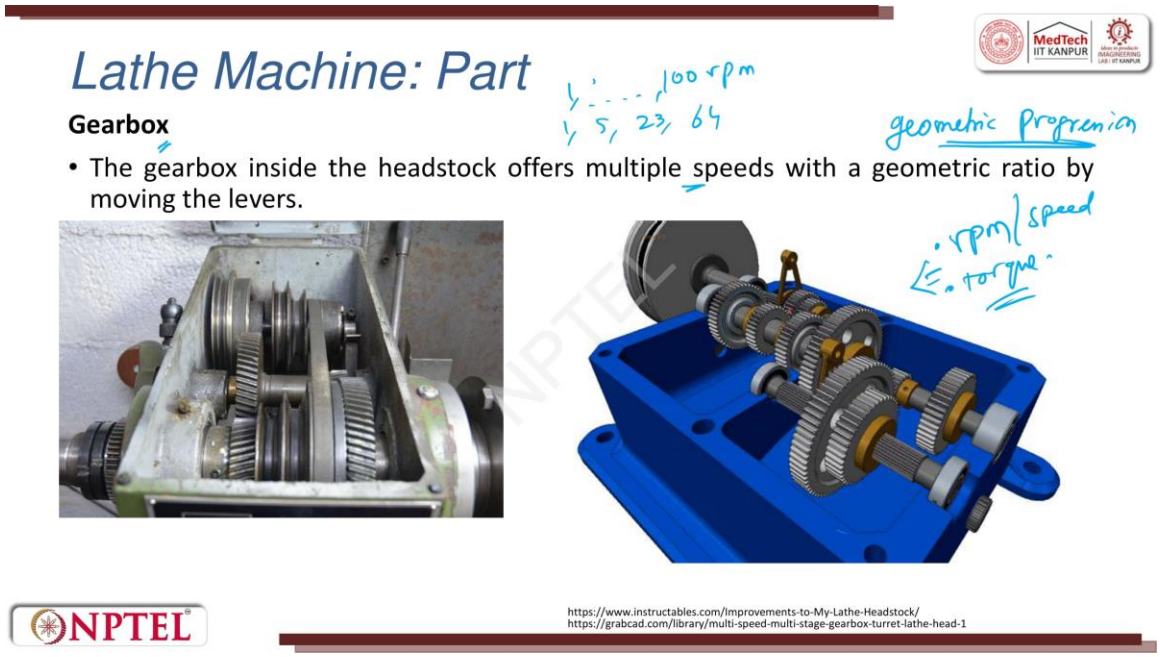
So, next comes the important component bed. We have not discussed till now about the bed. So, this is the headstock. This is the tailstock.

And till now we have discussed about the suck. Now, all these fellows have to rest on something. The resting part is called as the bed. The main part of a lathe are usually made of cast iron. This is bed.

Provides a heavy rigid frame on which all the main components are mounted. All the parts are finally bolted to the bed. It includes headstock, tailstock, carriage, this is a carriage, and the lead screw, feed rod, etc., etc.. It also consists of lead screw, feed rod and rack and pinion on the bed weight. So, rack and pinion is this is attached to the carriage.

So, you have a rack that moves on, and you rotate it. There is a rack that helps you in moving. The size of the lathe is designated by the swing diameter. We always talk about the swing diameter of the chuck. The size of the lathe is designated by the swing and the maximum distance between the headstock and the tailstock, between the centers.

So, these two are used for specifying a lathe: the length between the two centers and the swing diameter. They are basic. Apart from that, you talk about the motor rating and other things.



The next important thing is the gearbox. Where does the gearbox come in? The motor is attached to a gearbox. This gearbox, in turn, is attached to a spindle. Why? You try to change the RPM. You try to change the torque.

So, speed is changed and the torque is changed. So, when you want to give a higher depth of cut, you need a higher torque. So, correspondingly what we do is, we try to reduce the speed. So, the gearbox inside the headstock offers multiple speeds with a geometric ratio by moving the lever. So, what we are talking about is geometric progression.

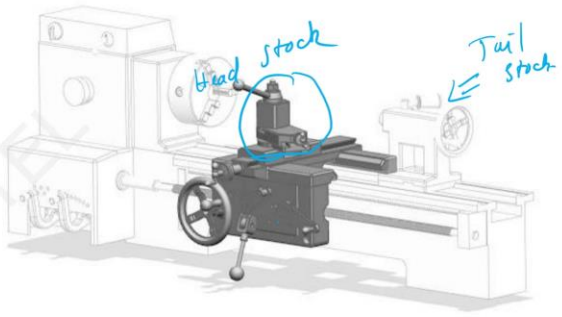
So, why is it important? Can I get speeds from 1 to 100 RPM continuous? No, not possible. You will get maybe 1, then 5, then 23, then 64, something like that. So, what is this?

This is geometric progression. These numbers do not match but I am just giving you these jumps are there. So, this means there is a geometric progression and this geometric progression comes from the combination of gears placed in the gearbox.

Lathe Machine: Part

Carriage

- The carriage is located between the headstock and the tailstock and contains
  - An apron
  - Saddle
  - Compound rest
  - Cross slide and
  - Tool post
- Moves on the outer ways.
- Used for mounting and moving most of the cutting tools.



http://toolnotes.com/home/machining/lathes-101/major-lathe-components/carriage-components/

The carriage; So, the carriage is the place where the tool post is mounted. The carriage is located between the headstock and the tailstock. This is the tailstock. It contains an apron, a saddle, a compound rest, a cross slide which moves, and a tool post. As we saw, the tool post is a place where we mount the tool. Then, the cross slide is this section. It moves on the outer way, used for mounting and moving the tool post for the cutting tool. This is done by the carriage.

Lathe Machine: Part

Feed rod & Lead screw

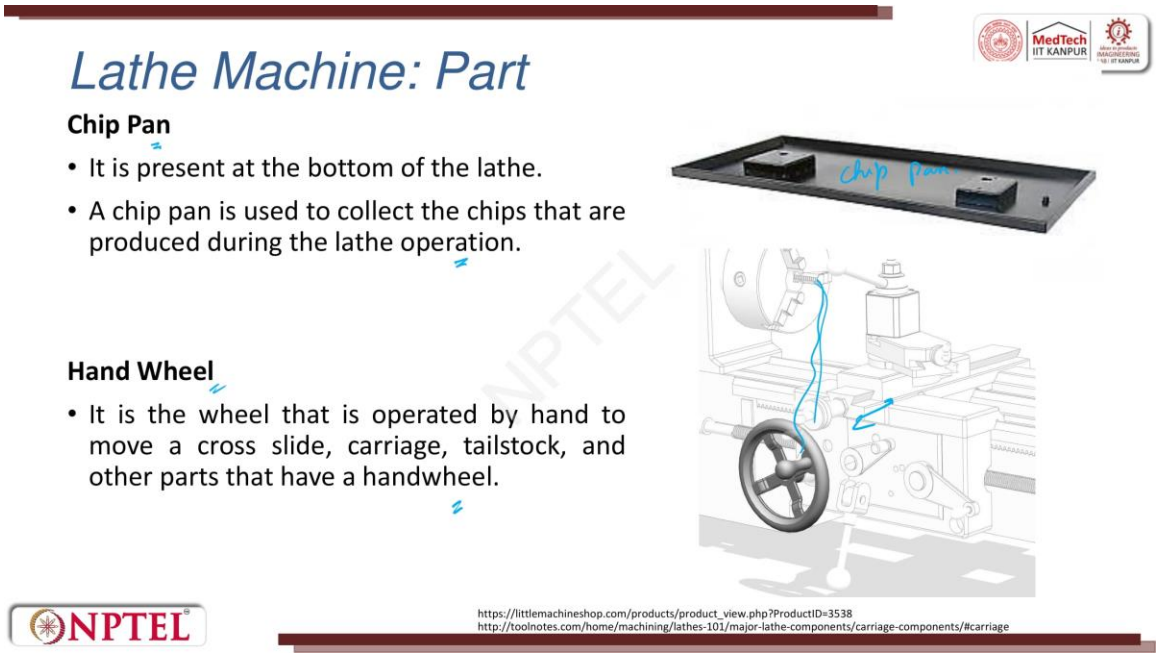
- The lead screw is used to move the carriage automatically during threading.
- Used to connect the feed box and slide box, and transmit the speed and power of the feed box to the slide box, so that the slide box achieves longitudinal linear motion.

http://colnet.ddns.net/Machine%20Manufacturing%20L3/Topic%204/Topic%204.1.htm
https://www.homemadetools.net/forum/straightening-lathe-feed-rod-28724

The next two important parts are the feed rod and the lead screw. The lead screw is used to move the carriage automatically during threading. The feed rod is used to connect the feed box and the slide box and transmit the speed and power from the feed box to the slide box, so that the slide box achieves longitudinal linear motion.

So, this is the lead screw. And this is the feed rod. And this is the rack which I was trying to tell you about. So, when we have a rack, you have a rack and pinion.

This is a rack. So, the carriage will be mounted to a pinion. So, when you rotate the handle, it will get meshed with a rack and then it will try to move forward. So, this is the place where carriage is sitting and then carriage handle comes into existence. So, this is a rack, a feed rack and this is a lead screw and this is the feed rod. So, lead screw is used for threading, feed rod is used for automatic threading.



There is a chip pan as I told you. It is at the bottom. So, where all the chip from the machining, it falls down, it goes to chip pan. So, then the chip pan is removed.

We remove the chip. It is present at the bottom of the lathe. The chip pan is used to collect the chip that can be produced during the lathe operation. A hand wheel which is there. It is a wheel that is operated by hand to move the cross slide, carriage and tailstock and other parts with the handwheel. So, the handwheel is very important because when you rotate it, this, in turn, tries to give you linear motion.

Lathe Machine: Part

Cooling device

- The cooling device primarily uses a cooling water pump to
  - suppress the slotted fluid in the water tank and spray it to the cutting location,
  - wash the chips, and
  - lower the cutting temperature.
  - lubrication
- It smoothens the surface to improve tool and service life.

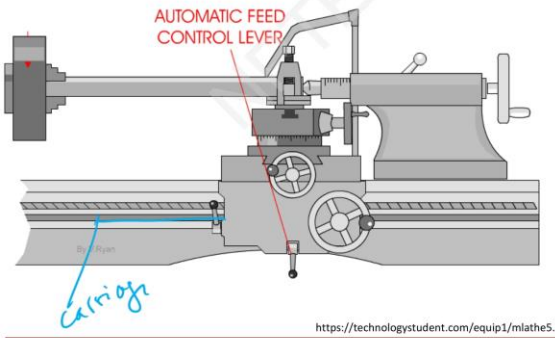
https://cncwmt.com/product/coolant-system-accessories-for-lathe-mill-drill-2/

Then, the cooling device, a cooling device primarily, is used as a cooling water pump. It tries to supply cutting fluid at the location. This cutting fluid, whatever is supplied here, is used for washing the chips, lowering the temperature, and also for lubrication to reduce the friction between the tool and the workpiece. It smoothens the surface and improves the tool life and service conditions.

Lathe Machine: Part

Slide box

- This is the control box for the feed movement of the lathe.
- It is furnished with a mechanism that turns the rotary motion of the light rod and the lead screw to the linear motion of the tool post.



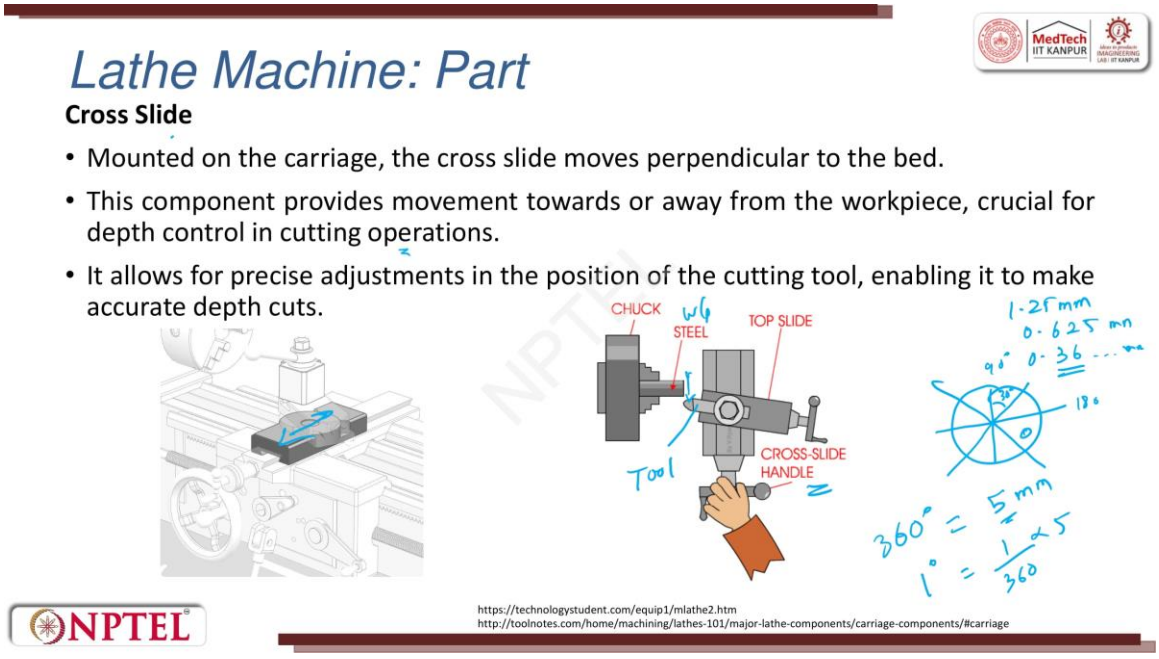
https://technologystudent.com/equip1/mlathe5.htm

Then, you have the slide box. It is the control box for the feed movement of the lathe. It is furnished with a mechanism that turns the rotary motion of the lead rod and the lead screw into the linear motion of the tool post. So, there are two things which we are talking about. So, the slide box; this is the slide box, the carriage is there.

So, now you rotate the handle. So, there is a feed rod and the lead screw. So, this is used; the slide box is used. It is the control box for the feed movement of the lathe. So, what is feed?

The rate at which the tool moves when it comes in contact or while it is machining. So, this is called the feed rate. So, this can generally be written in mm per minute or mm per revolution. So, what is the advancement you get in one minute? So, the feed movement of the lathe.

These two are feed rates. When we talk about feed movement, it is only in millimeters. This is the feed rate. This is the feed. It is furnished with a mechanism that turns the rotary motion of a lead screw into the linear motion of the tool post. This is the tool post.



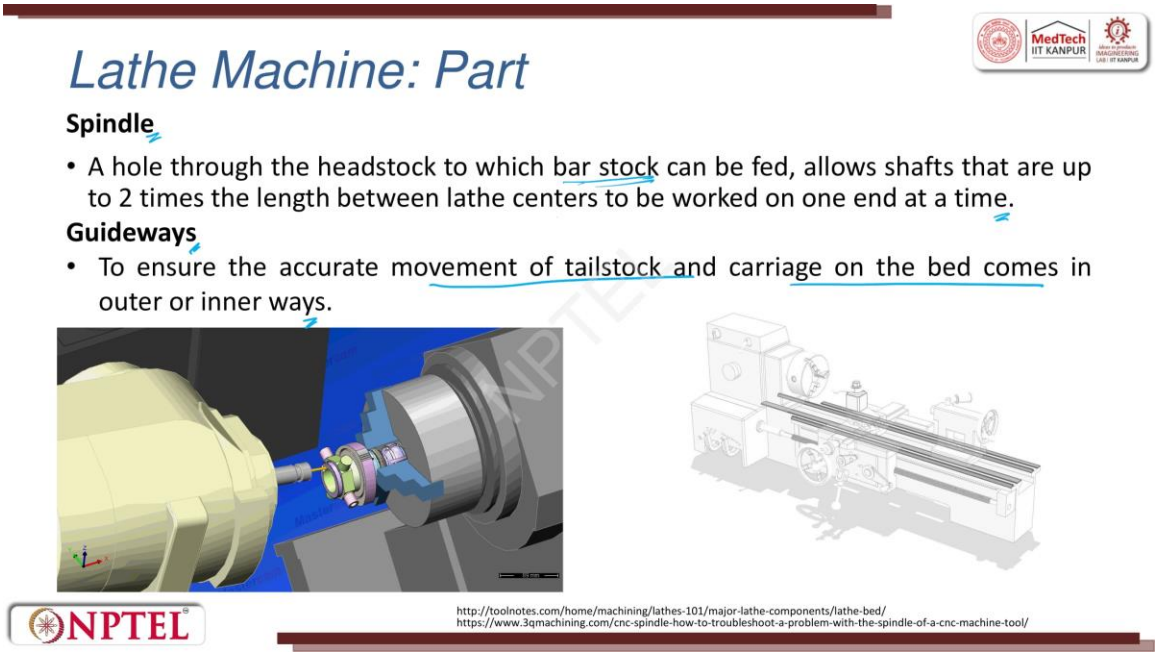
Cross slide. As I told you, the cross slide moves perpendicularly. Cross slide. Mounted on the carriage, this is the cross slide handle. This is the top; you have the tool. This is the tool, this is the workpiece, and this is the chuck. So, the tool is moving in this direction.

So, that is because of the cross slide, whatever is there. Mounted on the carriage, the cross slide moves perpendicular to the bed. This is the carriage.

This is the carriage. This compound provides movement toward or away from the workpiece, crucial for the depth control of the cutting operation. It allows for precise adjustment in the position of the cutting tool. So, that means when you rotate one round on the handle, this is 360 degrees. When you rotate it, it can advance by 5 mm.

So, now you can try to figure out for 1 degree what the advancement will be. It will be 1 by 360 into 5 for 1 degree. So, now this handle is divided into several segments. So, this is 30 degrees. Now if you see, this is for 1 degree I can find out, then if I want to do for 30 degrees, I will multiply it by 30.

Now I can divide the 5 millimeter into several small things. For example, one rotation is 5 millimeter, half the rotation is 2.5 millimeter, quarter of it is going to be 1.25 millimeter. Quarter is what? So, half is 180 degrees, quarter is 90 degrees. Quarter is 1.25 millimeter. Now, I am going to go half of it, that is 45, that is nothing but 0.625 millimeter. Now, I am going to go half of it. So, that is going to be 0.16 something millimeter. So, now you see how precisely in the linear motion you get when you try to rotate it.

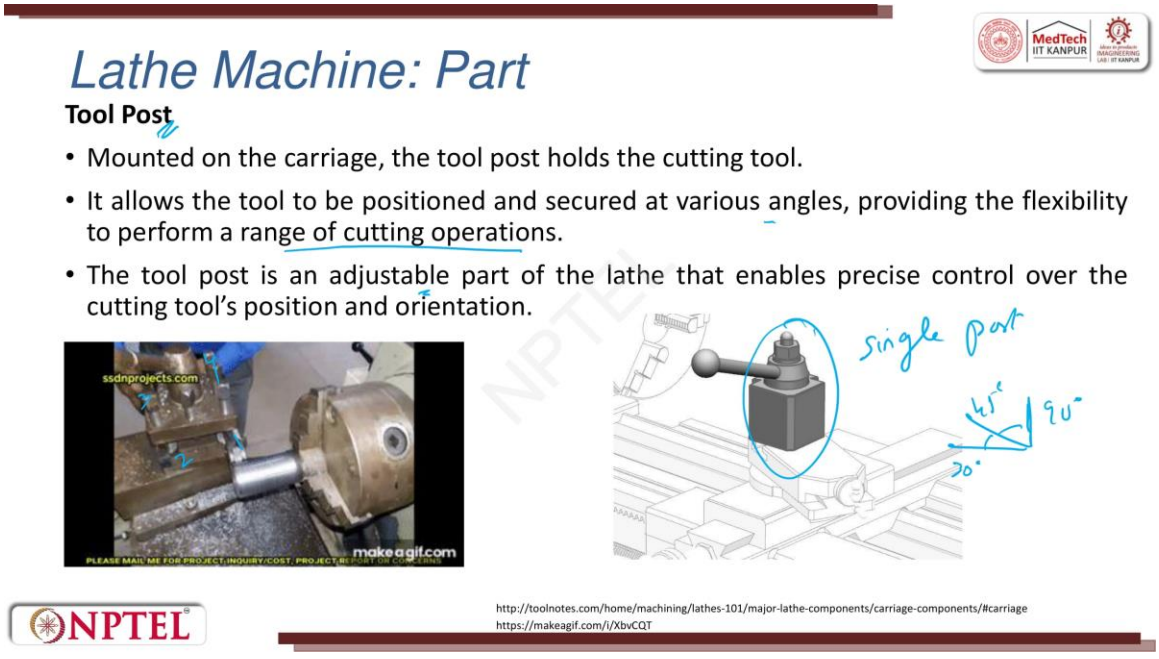


So, spindle; a hole through the headstock to which bar stock can be fed. So, generally it will be a hollow shaft. A spindle is there, the three jaws come and when three jaws meet also you will have a small gap in the center. So, now through which you can feed the rod. So, that is what is told as the hole through the headstock to which bar stock can be fed. For example, you continuously feed a bar.

Then, once a certain amount is done, it will truncate, it will make a bolt or a nut or a screw, can be fed, allows the shaft that are up to two times the length between the lathe centre to be worked on one end at a time, right. So, this is called the spindle.

The spindle is a hollow spindle. When I say hollow, there can be material coming from here. Here, you will have a spindle. So, this center portion is a bar stock. When you want to do continuous operation, for example, making bolts, then we use this bar stock, nuts bar stock.

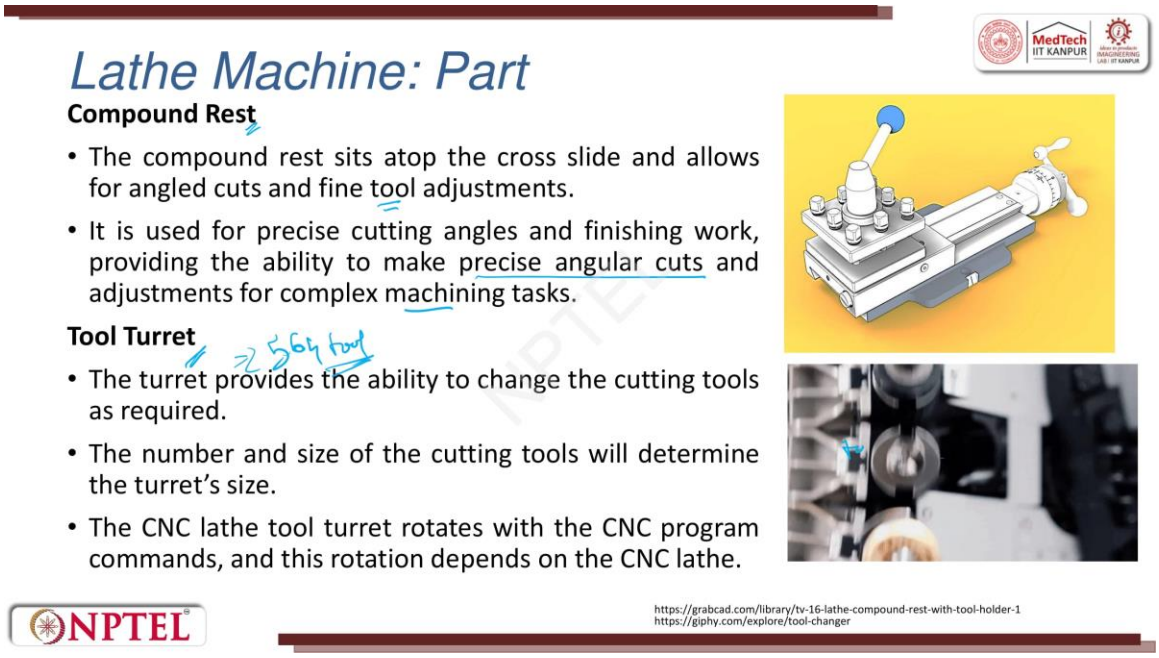
So, guideway. Guideway is a place where the cross slide sits on it and is guided so that there is no deviation. To ensure the accurate movement of the tailstock and the carriage on the bed, coming in and out of the way is done by the guideway.



Then, the tool post we have discussed enough. So, here this is a single tool post, and here you can see one, you can place it here, two, then three, and four.

So, there are four tools which can be kept on a tool post. Mounted, this tool post is mounted on the carriage; the tool post holds the cutting tool. It allows the tool to be positioned and secured at various angles. So, you can try to rotate it. So, it can be at 0, it can be at 90 degrees, it can be at 45 degrees, it can be at 30 degrees, it can be any of those angles.

Mounted on the carriage, the tool post holds the cutting tool. It allows the tool to be positioned and secured at various angles, providing the flexibility to perform a range of cutting operations. The tool post is an adjustable part of the lathe machine.



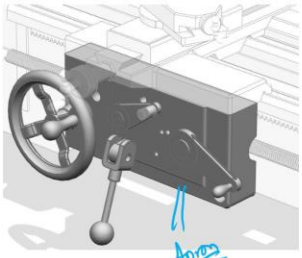
Compound rest. The compound rest sits atop the cross slide and allows for angled cuts and fine tool adjustments. It is used for precise cutting angles and finishing work. It provides the ability to make precise angular cuts and adjustments for complex machining tasks. Tool turret: if there is a restriction for four, then you can always have a turret. In modern-day CNC machines, they have a tool turret where you can load up to 564 tools at once. It is loaded.

Only one tool will engage for machining. The turret provides the ability to change the cutting tool as required. So, this is the turret. The number and size of the cutting tools will determine the turret size. The CNC lathe machine automatically calls the turret, and then the tool is picked and placed for machining.

Lathe Machine: Part

Apron

- The apron is part of the carriage that houses the control mechanisms.
- It contains gears, clutches, and levers used to control the movement of the carriage and the cross slide.
- The apron is essential for the operator to control and adjust the carriage's position and motion during machining operations



https://www.gatewaytoairguns.org/GTA/index.php?topic=179917.0
http://toolnotes.com/home/machining/lathes-101/major-lathe-components/carriage-components/#carriage

The apron is a part of the carriage that houses the control mechanism. It contains gears, clutches, and levers, which are used for the movement of the carriage and the slide automatically. The apron is essential for the operator to control and adjust the carriage position and motion during the machining operation. So, this is the apron.

Thank you.