TVET CERTIFICATE IV in PRODUCTION TECHNOLOGY

LATHE MACHINE OPERATIONS

PRTLO401

Perform lathe machine operations

Competence

REQF Level: 4

Learning hours: 120

Credits: 12

Sector: Mining and Manufacturing

Sub-sector: Production technology

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Purpose statement

This is a specific module which describes the performance outcomes, skills knowledge and attitude required to perform Lathe machine operations for lathe machine operator.

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Total number of pages: 125

Learning Unit 1- Analyse the work to be done

LO 1.1 Identify the work

- **Content/Topic 1: Types of materials**

INTRODUCTION

The materials used to manufacture of articles or products, dictates which manufacturing process or processes are to be used to provide it the desired shape. Sometimes, it is possible to use more than one manufacturing processes, then the best possible process must be utilized in manufacture of product. It is therefore important to know what materials are available in the universe with it usual cost. What are the common characteristics of different materials such as physical, chemical, mechanical, thermal, optical, electrical, and mechanical.

How they can be processed economically to get the desired product. The basic knowledge of materials and their properties is of great significance for a design and manufacturing. The elements of tools, machines and equipment should be made of such a material which has properties suitable for the conditions of operation. In addition to this, a product designer, tool designer and design technician should always be familiar with various kinds of engineering materials, their properties and applications to meet the functional requirements of the design product. They must understand all the effects which the manufacturing processes and heat treatment have on the properties of the materials.

Metals and Nonmetals are different types of materials present around us. ***Elements can be divided into metals and nonmetals*** and it is important to know whether a particular element is a metal or nonmetal. Metals (like copper and aluminium) are good conductors of heat and electricity, while nonmetals (such as phosphorus and sulfur) are insulators. Materials are distinguished as above, based on their properties.

a) Metals

With the exception of hydrogen, all elements that form positive ions by losing electrons during chemical reactions are called metals. Thus metals are electropositive elements with relatively low ionization energies. They are characterized by bright luster, hardness, ability to resonate sound and are excellent conductors of heat and electricity. Metals are solids under normal conditions except for Mercury.

Metals are materials holding or possessing the characteristics of being shiny, hard, fusible, malleable, ductile, etc. Few examples of metals (materials) are – Gold, Silver, Aluminium, Copper, Iron, etc.

Uses of Metals

The many uses of Metals are:

- ✓ Metals are used for various purposes, from making wires and sheets. For example – Copper and aluminum wires in electrical equipment’s, especially for conduction of electricity.
- ✓ Metals are also used in making automobiles, machinery, water boilers, industrial gadgets, etc.

- ✓ The metals are used in making utensils and water boilers due to its property of being a good conductor of heat.

b) Nonmetals

Elements that tend to gain electrons to form anions during chemical reactions are called non-metals. These are electronegative elements with high ionization energies. They are non-lustrous, brittle and poor conductors of heat and electricity (except graphite). Non-metals can be gases, liquids or solids.
Non – metals are materials not holding the characteristics of metals, means they are not shiny, hard, fusible, malleable, ductile, etc. Many materials like coal and Sulphur are very soft and dull in appearance. They break down into very fine thin powdery mass on tapping with the hammer. They are neither in – sonorous and also are a very poor conductor of heat and electricity. Few examples of non – metals are carbon, oxygen, Sulphur, etc.

Uses of Non Metals

- ✓ Many non-metals like chlorine, Sulphur, iodine are very useful for medicinal purposes.
- ✓ Non-metal like oxygen is very essential for our life for respiration.
- ✓ We use nitrogen phosphorus in fertilizers for better plant growth and enhance the fertility of the soil.
- ✓ Non-metal like Sulphur is useful in crackers.
- ✓ Chlorine and Fluorine are useful for the water purification purpose.

Metals and Alloys

Metals are polycrystalline bodies consisting of a great number of fine crystals. Pure metals possess low strength and do not have the required properties. So, alloys are produced by melting or sintering two or more metals or metals and a non-metal, together. Alloys may consist of two more components. Metals and alloys are further classified into two major kind namely ferrous metals and non-ferrous metals.
(a) Ferrous metals are those which have the iron as their main constituent, such as pig iron, cast iron, wrought iron and steels.
(b) Non-ferrous metals are those which have a metal other than iron as their main constituent, such as copper, aluminium, brass, bronze, tin, silver zinc, invar etc.

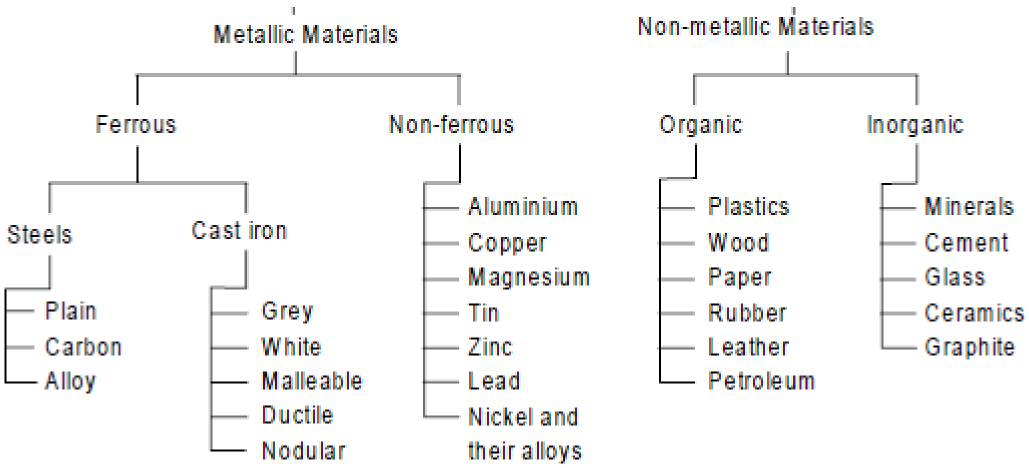


Figure 1: Different Type Of Material Flow Chart

- **Content/Topic 2- Workpiece dimensions interpretation**

The diameter is the length of the line through the center that touches two points on the edge of the circle.
Width the measurement or extent of something from side to side; the lesser of two or the least of three dimensions of a body
Length is the term used for identifying the size of an object or distance from one point to Length is a measure of how long an object is or the distance between two points. It is used for identifying the size of an object or distance from one point to another. The length of an object is its extended dimension, that is, its longest side.
The given image is of a rectangle, and for every rectangle, the length is longer than its breadth.
Thickness: is defined as the distance through an object, as distinct from width or height.

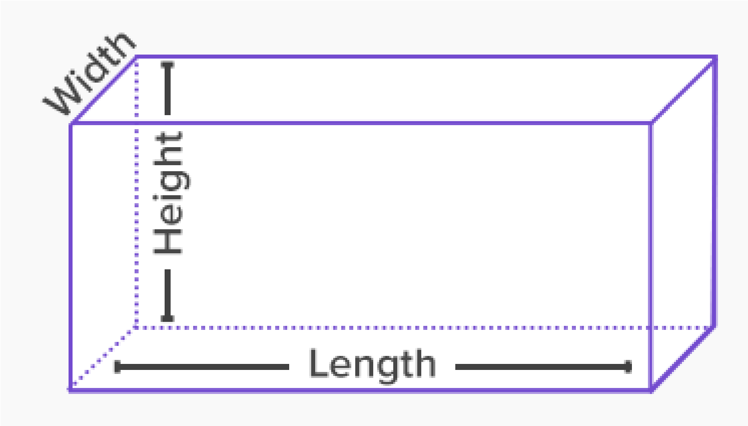


Figure 2show length, height and width

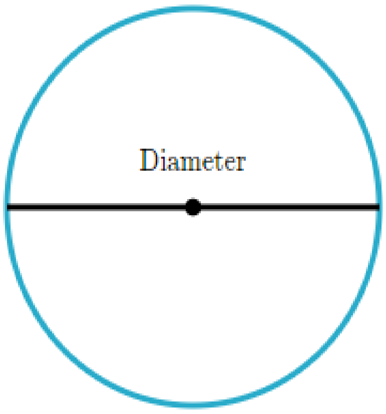


Figure 3 diameter of the circle

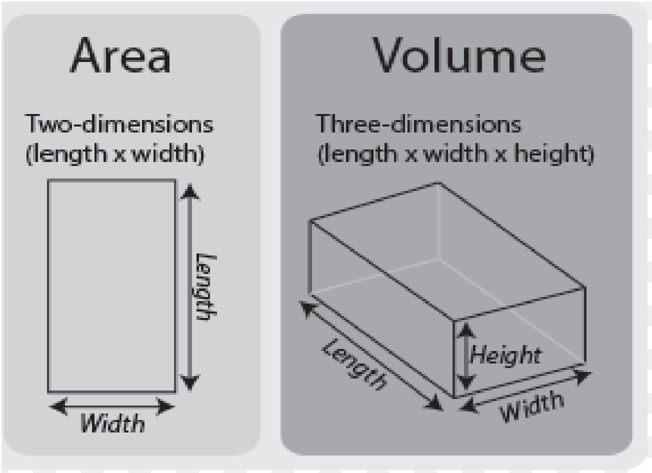


Figure 4 Area and volume Dimensions

(Singh, 2006)

LO 1.2 Identify material properties

- **Content/Topic 1: Type of Materials**

1. Metal

Ferrous metals are iron base metals which include all variety of pig iron, cast iron wrought iron and steels. The ferrous metals are those which have iron as their main constituents. The ferrous metals commonly used in manufacturing practice are cast iron, wrought iron, steel and alloy steels. The basic principal raw material for all ferrous metals is pig iron which is obtained by smelting iron ore, coke and limestone, in the blast furnace.

Main Types of ferrous Metal

1. Pig iron
2. Cast iron
   - White cast iron
   - Gray cast iron
   - Malleable cast iron
   - Ductile cast iron
   - Meehanite cast iron
   - Alloy cast iron
3. Wrought iron
4. Steel
   - Plain carbon steels

a) Dead Carbon steels

b) Low Carbon steels

c) Medium Carbon steels
d) High Carbon steels

- Alloy steels

a) High speed steel
b) Stainless steel

Non-ferrous Metals

We have already discussed that the non-ferrous metals are those which contain a metal other than iron as their chief constituent. The non-ferrous metals are usually employed in industry due to the following characteristics:

- ✓ Ease of fabrication (casting, rolling, forging, welding and machining),
- ✓ Resistance to corrosion,
- ✓ Electrical and thermal conductivity, and
- ✓ Weight.

The various non-ferrous metals used in engineering practice are aluminium, copper, lead, tin, zinc, nickel, etc. and their alloys.

2. Non-metallic Materials

The non-metallic materials are used in engineering practice due to their low density, low cost, flexibility, resistant to heat and electricity. Though there are many non-metallic materials, yet the following are important from the subject point of view.

- ❖ **Wood**

Wood is a porous and fibrous structural tissue found in the stems and roots of trees and other woody plants. It is an organic material – a natural composite of cellulose fibers that are strong in tension and embedded in a matrix of lignin that resists compression.

We have two categories of wood; Soft wood and homing in on hardwoods

a) Soft wood

Softwoods aren’t weaker than hardwoods. Softwoods come from coniferous trees such as cedar, fir, and pine and tend to be somewhat yellow or reddish. Because most coniferous trees grow fast and straight, softwoods are generally less expensive than hardwoods.

Following is a list of common softwood varieties

- ➢ Cedar
- ➢ Fir
- ➢ Pine
- ➢ redwood

b) Hardwoods

Most woodworkers love to work with hardwoods. The variety of colors, textures, and grain patterns makes for some beautiful and interesting-looking furniture. The downside to hardwoods is their price. Some of the more exotic species can be too expensive to use for anything more than an accent. Following is a list of common hardwoods:

- Ash
- Birch
- Cherry
- Mahogany
- Maple
- Oak
- Poplar
- Teak
- walnut

- **Plastics.**

The plastics are synthetic materials which are moulded into shape under pressure with or without the application of heat. These can also be cast, rolled, extruded, laminated and machined. Following are the two types of plastics:

(a) Thermosetting plastics, and
(b) Thermoplastic.

The **thermosetting plastics** are those which are formed into shape under heat and pressure and results in a permanently hard product. The heat first softens the material, but as additional heat and pressure is applied, it becomes hard by a chemical change known as phenol formaldehyde
(Bakelite), phenol-furfural (Durite), urea formaldehyde (Plaskon), etc.

The **thermoplastic** materials do not become hard with the application of heat and pressure and no chemical change occurs. They remain soft at elevated temperatures until they are hardened by cooling. These can be remelted repeatedly by successive application of heat. Some of the common thermoplastics are cellulose nitrate (Celluloid), polythene, polyvinyl acetate, polyvinyl chloride (P.V.C.), etc.
The plastics are extremely resistant to corrosion and have a high dimensional stability. They are mostly used in the manufacture of aeroplane and automobile parts. They are also used for making safety glasses, laminated gears, pulleys, self-lubricating bearing, etc. due to their resilience and strength.

- **Stone**

Stone is the hard substance, formed of mineral matter, of which rocks consist. A rock or particular piece or kind of rock, as a boulder or piece of agate. A piece of rock quarried and worked into a specific size and shape for a particular purpose: paving stone; building stone. A small piece of rock, as a pebble.
Precious stone.

LO 1.3 Estimate the cost

- **Content/Topic 1: Definition of BOQ**

A bill of quantities is a document used in tendering in the construction industry in which materials, parts, and labor (and their costs) are itemized. It also (ideally) details the terms and conditions of the construction or repair contract and itemizes all work to enable a contractor to price the work for which he or she is bidding. The quantities may be measured in number, area, volume, weight or time. Preparing a bill of quantities requires that the design is complete and a specification has been prepared.

A bill of quantities (**BOQ**) An itemized list of materials, parts, and labor (with their costs) required to construct, maintain, or repair a specific structure

Advantages of a BoQ (Bill of Quantities).

- A BoQ is prepared a cost constantly. This detail to measured **quantities of identified by specification and drawing** in the tender documentation for construction works.
- A BoQ is issued to tenderers for them to prepare a price for carrying out the works. **BoQ assists tender** in the calculation of construction costs for their tender because all tendering contractors will price the same quantities. BoQ provides a fair and accurate system for tendering
- Before construction begins, the BoQ may notify the project budget along with also the modification of any elements of this design, which might be prohibitively expensive. Additionally, it may help clarify quantities so the correct materials could be secured ahead of their works starting.
- A BoQ is also as a reliable base for budget control and accurate cost reporting.
- BoQ enables the preparation of cash **flow forecast** and provide a basis for the valuation of variation, the preparation of interim payments, and the final account.
- BoQ helps create a low cost and low risk for tendering environment, which encourages the submission of competitive bids since the risk is better understood and defined.

- **Content/Topic 2: Element of Bill Of Quantity**

The main sections included in the bill of quantities are Form of Tender, Information, Requirements, Pricing schedule, Provisional sums, and Day works. For the preparation of BOQ, main components are to be considered which are as follows:

Full bill of quantity should be composed by the following elements

- ✓ Serial number
- ✓ Items/Descriptions
- ✓ Item Specifications
- ✓ Quantity
- ✓ Unity price
- ✓ Total price
- ✓ Labor cost 30% of material total price Taxes
- ✓ Transport

- ✓ Grand total
- ✓ Contingencies

- **Serial number**

A serial number is a unique identifier assigned incrementally or sequentially to an item, to uniquely identify it. Serial numbers need not be strictly numerical.
They may contain letters and other typographical symbols, or may consist entirely of a character string.

Sometimes abbreviated as **Serial No.**, **SN** or **S/N**, a **serial number** is a unique number used for identification and inventory purposes. A **serial number** allows a company to identify a product and get additional information about it, for replacement, or as a means of finding compatible parts.

- **Items/Descriptions**

A good *item description* includes anything required to uniquely identify an *item* and no more. For instance, if the brand name of an *item* is important, then it should be in the *description* because it's different from a similar *item* of a different brand

- **Item Specifications**

A detailed description or assessment of requirements, dimensions, materials, etc., as of a proposed building, machine, bridge, etc. a particular item, aspect, calculation, etc., in such a description. Something specified, as in a bill of particulars; a specified particular, item, or article.

A specification often refers to a set of documented requirements to be satisfied by a material, design, product, or service. A specification is often a type of technical standard.

- **Unit Price**

A unit price is the price for one item or measurement, such as a pound, a kilogram, or a pint, which can be used to compare the same type of goods sold in varying weights and amounts. Multiple pricing is selling two or more of the same item at a price that is lower than the unit price of a single item.

- **Contingencies**

A future event or circumstance which is possible but cannot be predicted with certainty.
A contingency is a potential negative event that may occur in the future, such as an economic recession, natural disaster, fraudulent activity, or a terrorist attack. Contingencies can be prepared for, but often the nature and scope of such negative events are unknowable in advance. Companies and investors plan for various contingencies through analysis and implementing protective measures.

- **Content /Topic3: Format of BOQ**

Subject:				
Owner:				
A. Materials cost				
SN	**Items/Descriptions**	**Quantity**	**Unity price**	**Total price**
1				
2.				
				Sub Total 1
B. Labors cost				
SN	**Items/Descriptions**	**Quantity**	**Unity price**	**Total price**
1				
2				
				Sub Total 2
C. Transport Cost				
SN	**Items/Descriptions**	**Quantity**	**Unity price**	**Total price**
1				
2				
				Sub Total 3
D. Material total price Taxes				**Sub Total 4**
E. Contingencies				**Sub Total 5**
F. Grand total				**Sub Total 1+ Sub Total 2+ Sub Total 3+ Sub Total 4+ Sub Total 5**

- **Content /Topic 4: Definition of Invoice**

An invoice is a commercial document that itemizes and records a transaction between a buyer and a seller. **An invoice** is a document issued to customers by a seller asking for payment of goods or services. It is also known as a bill or tab. Invoice is a document presented to the customer before or after supplying the goods or services. It is a legal document that can be annulled with a credit note if issued incorrectly.

If you are a seller, you are not allowed to simply remove an invoice from sales records. Your Businesses is probably registered for VAT (value added tax) and you need to issue invoices in line with specific regulatory requirements.

An invoice, bill or tab is a commercial document issued by a seller to a buyer, relating to a sale transaction and indicating the products, quantities, and agreed prices for products or services the seller had provided the buyer. Payment terms are usually stated on the invoice.

- **Content /Topic 5: Element of Invoice**

An invoice, while not technically a binding legal document, is one of the most important documents your company will ever create. It directly affects when you get paid and on what terms those payments are made. Below are eight essential elements you must include to create an invoice that is both professional and effective.

Before preparing the invoice the following element should be available

1. **Company Information**

If you are the payer, you want to be sure that your company's legal name, business address, business phone number and fax number (if applicable) are listed accurately and included near the top and bottom of the invoice. If you are the payee, you want to be sure to include the same information at the top and bottom of the invoice as well. You want to be sure to differentiate which company is the payer and which is the payee by labeling each. As the one making the payment, you should label the payee as "Sold To"; this indicates who is responsible for making the payment.

2. **Header**

This may seem blindingly obvious, but be sure to label your document as an invoice in the header. This way, you minimize any confusion about what the document is, especially if it's part of a pile of otherwise indistinguishable papers.

3. **Date, Invoice Number and Unique Identifier**

Along with each company's respective payer and payee information, you'll want to include the date on which the invoice is issued and an invoice number or another unique identifier. You can structure your ID based on any system or stylistic preference, whether it's a simple file number, unique billing code or date-based purchase order number. If you are the one sending the invoice to an organization and asking for payment, perhaps for freelance work, check with the organization to see if there are any unique company details they need included, such as an internal purchase order (PO) number or billing code. For many larger organizations, PO numbers and/or billing codes are the only way they can expediently deal with an invoice. Details like these can mean the difference between getting paid on time and getting paid next quarter.

4. **Tin number**

A Taxpayer Identification Number (**TIN**) is a unique nine-digit number used to identify an individual, business, or other entity in tax returns and other documents filed with the Internal Revenue Service (IRS) RWANDA REVENUE AUTHORITY in Rwanda.

5. **Client's information**

6. **List of Goods and Services**

This section of the invoice can be as detailed or generic as you like. The most important parts of the listing include:

- ✓ Name of the good or service provided
- ✓ Date the good or service was provided
- ✓ Rate for the good or service provided
- ✓ Quantity of the good or service provided
- ✓ You may want to consider adding sub-sections for each item that includes price modifications, item descriptions or other information as needed.

7. Terms

Terms of payment are incredibly important on an invoice. Standard payment terms will vary based on your industry, your company's preference and, perhaps most importantly, your relationship with the client. It's also important to make mention of the penalties if these terms are not met. This could include a late fee or an additional percentage of the total bill.

8. Itemized Fees

If there are any taxes, handling fees or other charges that need to be levied, each of these should be listed as a separate line item. This is important for some organizations that need to apply these different fees to different budgets for their internal books to balance.

9. Total Amount Due

While it may seem trivial, it's worth mentioning: Make sure that the total amount due is prominently displayed on the invoice.

10. Add-Ons

While the previous seven items are really important to include on an invoice, there are a few other elements you can include if you choose, such as:

- ✓ **Message Field**: This can be used to say "thank you" to a client or make reference to something unique to the project.
- ✓ **Tax Identification Number**: Some businesses may file their invoices using their clients' TIN. Since it is a government-issued number that is unique to each business, it's worth including, especially if you handle a high volume of invoices.

11. Account number

An account number is a unique string of numbers and, sometimes, letters and other characters that identifies the owner of an account and grants access to it.

12. Delivery details

Delivery details is a document that accompanies a goods shipment and lists details about the goods delivered. A delivery note explains what the contents of a package are. If some goods that were ordered are not enclosed (due to lack of stock, unavailability, etc.) they will also be listed on the delivery note. Where delivery note is a document that accompanies a goods shipment and lists details about the goods delivered.

A delivery note explains what the contents of a package are. If some goods that were ordered are not enclosed (due to lack of stock, unavailability, etc.) they will also be listed on the delivery note. This way the recipient will have an overview of what they ordered and what has actually been sent to them

Learning Unit 2: Identify machine, equipment and tools

LO 2.1 Identify turning machines

- **Content/Topic 1: Introduction to Turning**

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helix toolpath by moving more or less linearly while the workpiece rotates.

Usually the term "turning" is reserved for the generation of *external* surfaces by this cutting action, whereas this same essential cutting action when applied to *internal* surfaces (holes, of one kind or another) is called "boring". Thus the phrase "turning and boring" categorizes the larger family of processes known as lathing. The cutting of faces on the workpiece, whether with a turning or boring tool, is called "facing", and may be lumped into either category as a subset.

Turning can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using an automated lathe which does not. Today the most common type of such automation is computer numerical control, better known as CNC. (CNC is also commonly used with many other types of machining besides turning.)

When turning, the workpiece (a piece of relatively rigid material such as wood, metal, plastic, or stone) is rotated and a cutting tool is traversed along 1, 2, or 3 axes of motion to produce precise diameters and depths. Turning can be either on the outside of the cylinder or on the inside (also known as boring) to produce tubular components to various geometries. Although now quite rare, early lathes could even be used to produce complex geometric figures, even the platonic solids; although since the advent of CNC it has become unusual to use non-computerized toolpath control for this purpose.

The turning processes are typically carried out on a lathe, considered to be the oldest of machine tools, and can be of different types such as *straight turning*, *taper turning*, *profiling* or *external grooving*. Those types of turning processes can produce various shapes of materials such as *straight*, *conical*, *curved*, or *grooved* workpieces. In general, turning uses simple *single-point cutting* tools. Each group of workpiece materials has an optimum set of tool angles that have been developed through the years.

Lathe is one of the most versatile and widely used machine tools all over the world. It is commonly known as the mother of all other machine tool. The main function of a lathe is to remove metal from a job to give it the required shape and size. The job is securely and rigidly held in the chuck or in between centers on the lathe machine and then turn it against a single point cutting tool which will remove metal from the job in the form of chips.

- **Content/Topic 2: Types of Turning Machine**

Lathes are manufactured in a variety of types and sizes, from very small bench lathes used for precision work to huge lathes used for turning large steel shafts. But the principle of operation and function of all types of lathes is same.
The lathe machine is used to remove excess material from the workpiece so that the workpiece conforms to the desired style and size. Depending on the characteristics, the following types can be divided into several types: center lathes or engine lathes, speed lathes, capstan lathes or turret lathes, tool room lathes, bench lathes, automatic lathes, special lathes, and CNC lathes.

1. **Speed lathe machine:**
   The high-speed lathe can also be called a wood lathe, which can be operated at high speed and is operated manually. The speed range for high-speed lathes is approximately 1200 to 3600 RPM. This lathe is used for the rotation, centering, polishing and machining of wood working.

Figure 5: speed Lathe Machine

2. **Center lathe or engine lathe machine**
   This type of lathe that is currently widely used and can perform many operations such as turning, end face, tapering, grooving, knurling, and threading. The feed mechanism of the engine lathe can operate the cutting tool in both the longitudinal and lateral directions. The center lathe can be divided into belt drive, motor drive and reducer depending on the drive source.

Figure 6: center Lathe Machine

3. **Bench lathe machine**
   The small size of the bench lathe can be used for smaller and more precise work, with parts similar to engine lathes and high-speed lathes.

Figure 7: Bench Lathe

4. **Tool room lathe machine**
   The tool room lathe is similar to the engine lathe, but its parts are manufactured with great

precision and in order, so this machine is used for high precision grinding machining. It has a wide range of spindle speeds ranging from a very low to a quite high speed up to 2500 rpm. This lathe is mainly used for precision work on tools, dies, gauges and in machining work where accuracy is needed.

Figure 8: Tool Room Lathe

5. **Capstan and turret lathe machine:**
   Capstan and turret lathes are improvements in engine lathes that can be used for high volume production and for large jobs. The head of the machine tool is a hexagonal head, which can be rotated to change the operation without manual change, including turning, end face, boring and reaming.
   Capstan and turret lathes are semiautomatic lathes. Semiautomatic means machining is done automatically but some other functions like changing of job/work piece and setting of tools are done manually. These are the modified version of engine lathe. It is an example of advancement of technology in manufacturing industry. Construction of turret/capstan lathes is similar to engine lathe but difference is they have an axially movable index able turret having hexagonal shape in place of tail stock on which multiple tools are fitted. These tools are capable in performing multiple tasks like turning, boring, thread cutting, drilling and facing. By using these tools we can easily perform different type of operations on a single work piece without changing of tool and work piece. All these tools are mounted on a hexagonal turret; turret is rotates after each operation. Turret lathe is used for mass production and the advantage of this lathe is a less skilled operator can perform work on it once all setup is done properly. These types of lathes can be used for machining large work piece also. These lathes are relatively costlier than engine lathe because of their complex construction. Using these lathes a single type of job can be easily repetitive manufacture with less effort and time or we can say that both the lathes are used for mass production.

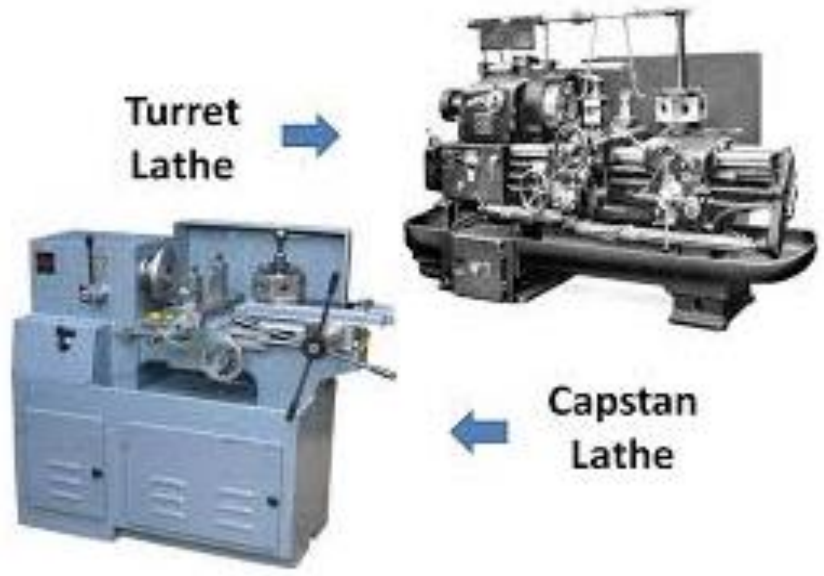


Figure 9: Capstan and Turret Lathe

6. **Special lathe machine**
   Special lathes are used to perform special operations that are not possible with the rest of the lathe. Special lathes include vertical lathes, wheeled lathes, T-type lathes, multi-axis lathes, production lathes, duplex or tracer lathes, etc., which are known for their heavy-duty production of the same parts.

7. **Automatic lathe machine**
   The automatic lathe can perform work automatically and can be used for mass production. The automatic machine will automatically change without having to change the tool manually. The advantage is that an operator can handle the operation of multiple machines at the same time. The automatic lathe is a high-speed and heavy-duty machine.

Figure 10: automatic Lathe

8. CNC lathe machine

The CNC lathe is used to control the operation of the machine tool through a computer program. Once the program is input in steps, mass production can be performed with high precision and high speed, and once the operation code is set, it can be produced without re-entering the next time. CNC lathes are the most advanced types of lathes available today, and the tolerances of the parts they produce are extremely precise.

Figure 11: CNC Lathe machine

(https://learnmechanical.com/lathe-machine/)

- **Content /Topic3: Description of Lathe Machine Main Components**

A simple lathe comprises of a bed made of grey cast iron on which headstock, tailstock, carriage and other components of lathe are mounted. The major parts of lathe machine are given as under:

1. Bed
2. Head stock
3. Tailstock
4. Carriage
5. Feed mechanism
6. Thread cutting mechanism

Different parts of engine lathe or central lathe

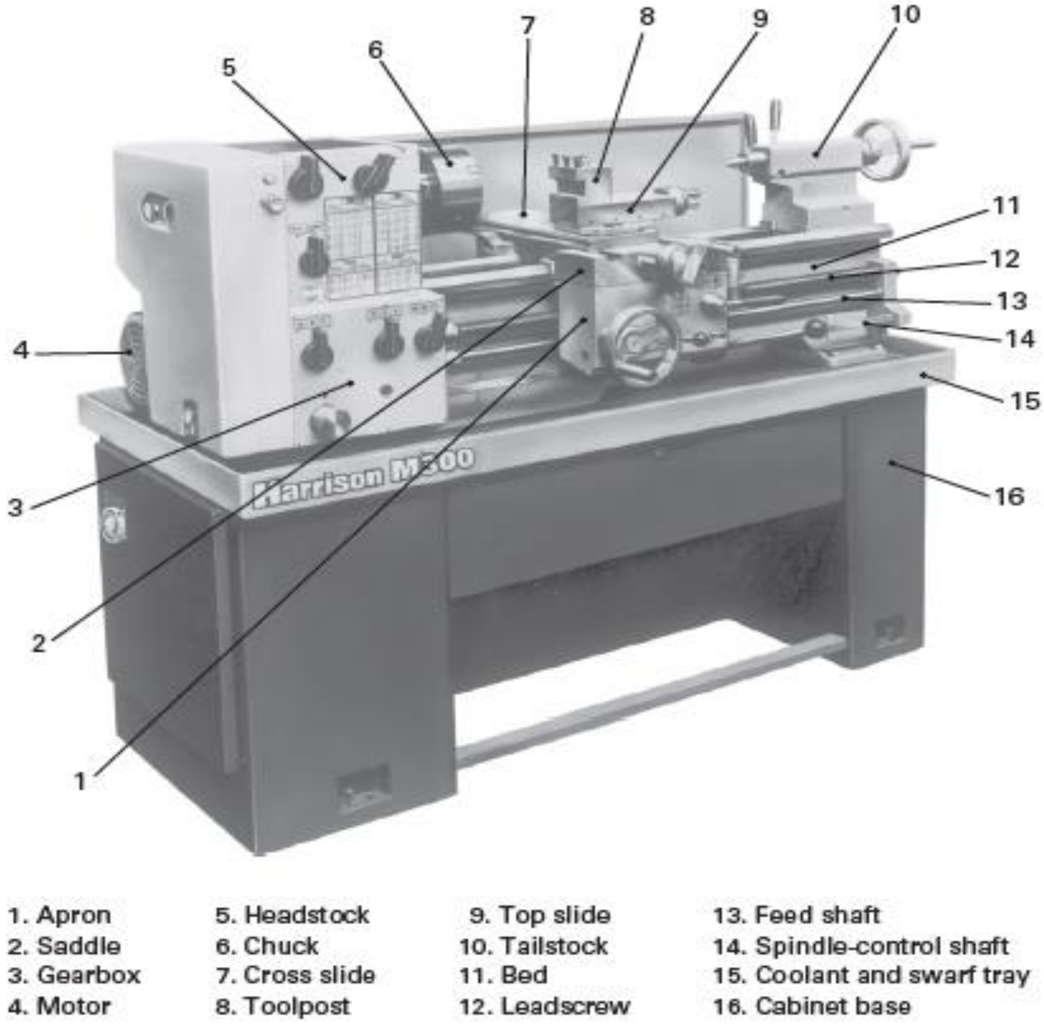


Figure 12: Parts of LATHE Machine

1. **Bed**

The bed of a lathe machine is the base on which all other parts of lathe are mounted. It is massive and rigid single piece casting made to support other active parts of lathe. On left end of the bed, headstock of lathe machine is located while on right side tailstock is located. The carriage of the machine rests over the bed and slides on it. On the top of the bed there are two sets of guideways-innerways and outerways. The innerways provide sliding surfaces for the tailstock and the outerways for the carriage. The guideways of the lathe bed may be flat and inverted V shape. Generally cast iron alloyed with nickel and chromium material is used for manufacturing of the lathe bed.

2. **Carriage**

The carriage is used for support, guide and feed the tool against the job when the machining is done.

- It holds moves and controls the cutting tool.
- It gives rigid supports to the tool during operations.
- It transfers power from feed rod to cutting tool through apron mechanism for longitudinal cross-feeding.
- It simplifies the thread cutting operation with the help of lead screw and half nut mechanism.

It is consists of:

- Saddle
- Cross-slide
- Compound rest
- Toolpost
- Apron

It provides three movements to the tool:

- Longitudinal feed-through carriage movement
- Cross feed-through cross slide movement
- Angular feed-through top slide movement

Carriage is mounted on the outer guide ways of lathe bed and it can move in a direction parallel to the spindle axis. The lower part of the carriage is termed the apron in which there are gears to constitute apron mechanism for adjusting the direction of the feed using clutch mechanism and the split half nut for automatic feed. The cross-slide is basically mounted on the carriage, which generally travels at right angles to the spindle axis. On the cross-slide, a saddle is mounted in which the compound rest is adjusted which can rotate and fix to any desired angle. The compound rest slide is actuated by a screw, which rotates in a nut fixed to the saddle.

The tool post is an important part of carriage, which fits in a tee-slot in the compound rest and holds the tool holder in place by the tool post screw.

Figure 13: Parts of Carriage

- **Saddle**

The saddle rests on top of the bed and is guided by two guideways which, for stability, are the two furthest apart. Accurate movement is thus maintained relative to the centre line of the spindle and tailstock for the complete length of the bed. The top surface contains the dovetail slideway into which the cross-slide is located and the cross-slide leadscrew, complete with handwheel and graduated dial.

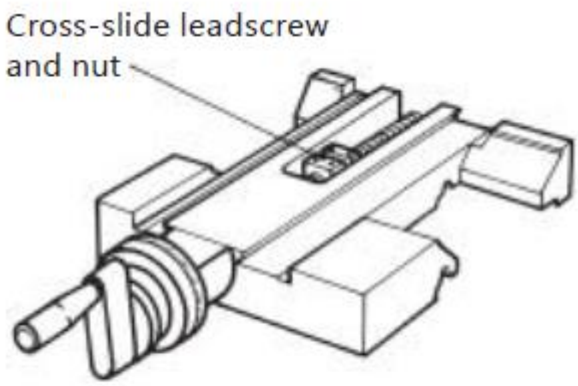


Figure 14: Saddle

- **Cross-slide**

Mounted in the dovetail slideway on the top surface of the saddle, the cross-slide moves at right angles to the centre line of the machine spindle. Adjustment for wear is provided by a tapered gib strip, which can be pushed further into the slide and slideway by the screw as wear takes place. Attached to the underside of the cross-slide is the leadscrew nut through which movement is transmitted from the leadscrew. Power feed is available to the cross-slide.

The top surface contains a radial tee slot into which two tee bolts are fitted. The central spigot locates the slideway for the top slide, which can be rotated and clamped at any angle by means of the tee bolts. Graduations are provided for this purpose.

On the lathe shown, external dovetails are provided along each side of the cross-slide, for quick accurate attachment of rear-mounting accessories.

- **Top slide**

The top slide is often referred to as the compound slide, fits on its slideway and can be adjusted for wear by means of a gib strip and adjusting screws. Movement is transmitted by the leadscrew through a nut on the slideway. A toolpost, usually four-way hand-indexing, is located on the top surface and can be locked in the desired position by the locking handle. Movement of this slide is usually quite short, 92 mm on the machine illustrated, and only hand feed is available. Used in conjunction with the swivel base, it is used to turn short tapers.

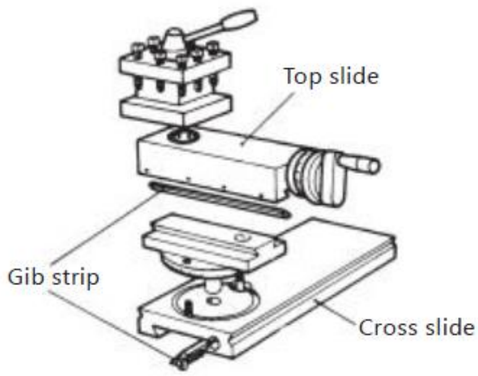


Figure 15: Top and Cross Slide

- **Apron**

The apron is attached to the underside of the saddle at the front of the machine and contains the gears for transmission of movement from the leadscrew and feed shaft.
Sixteen feed rates from 0.03 to 1 mm per revolution are provided. On the front are the handles to engage and disengage the leadscrew and feed shaft. Also mounted on the front is the handwheel for longitudinal traverse of the carriage along the bed, this movement being transmitted through gears to a rack fixed on the underside of the bed.
The complete assembly of apron, saddle and slides is known as the carriage. The spindle control on the apron is operated by lifting for spindle reverse, lowering for spindle forward and mid-position for stop.

- **Tool post of centre lathe**

It is the topmost portion of the carriage and it is used to hold various cutting tools or tool holders.
There are three types of tool post commonly used and those are:

- Ring and rocker tool post
- Square head tool post
- Quick change tool post

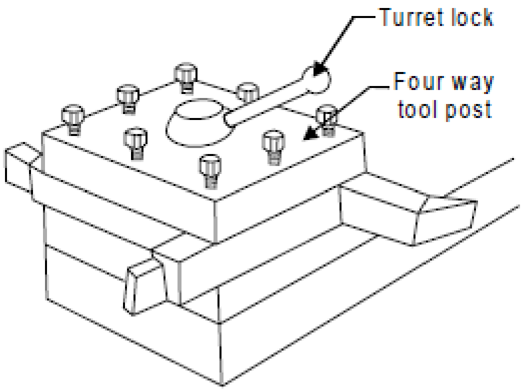


Figure 16: Tool post of centre lathe

3. **Head Stock**

The main function of headstock is to transmit power to the different parts of a lathe. It comprises of the headstock casting to accommodate all the parts within it including gear train arrangement. The main spindle is adjusted in it, which possesses live centre to which the work can be attached. It supports the work and revolves with the work, fitted into the main spindle of the headstock. The cone pulley is also attached with this arrangement, which is used to get various spindle speed through electric motor. The back gear arrangement is used for obtaining a wide range of slower speeds. Some gears called change wheels are used to produce different velocity ratio required for thread cutting.
Head Stock is situated at the left side of the lathe bed and it is the house of the driving mechanism and electrical mechanism of a Lathe machine tool.

It holds the job on its spindle nose having external screw threads and internally Morse taper for holding lathe center. And it is rotating at a different speed by cone pulley or all geared drive. There is a hole throughout spindle for handling long bar work.
Head Stock transmit power from the spindle to the feed rod, lead screw and thread cutting mechanism.
Accessories mounted on headstock spindle:

- Three jaw chuck
- Four jaw chuck
- Lathe center and lathe dog
- Collect chuck
- Faceplate
- Magnetic chuck

A separate speed change gearbox is placed below headstock to reduce the speed in order to have different feed rates for threading and automatic lateral movement of the carriage. The feed rod is used for most turning operation and the lead screw is used for thread cutting operation.

4. Tail Stock

Tail Stock is situated on the right side above the lathe bed.
The function of the tailstock is to hold a centre when turning between centres, or to act as a support at the end of long workpieces. Alternatively, the tailstock is used to hold drills and reamers when producing holes.
The tailstock can be moved on its guideways along the length of the bed and locked in any position. The quill contains a Morse-taper bore to accommodate centres, chucks, drills and reamers and is graduated on its outer top surface for use when drilling to depth. It can be fed in or out by means of the handwheel at the rear. Positive locking of the quill is carried out by means of a handle operating an eccentric pin.

The figure below shows the tail stock of central lathe, which is commonly used for the objective of primarily giving an outer bearing and support the circular job being turned on centers. Tail stock can be easily set or adjusted for alignment or non-alignment with respect to the spindle centre and carries a centre called dead centre for supporting one end of the work. Both live and dead centers have 60° conical points to fit centre holes in the circular job, the other end tapering to allow for good fitting into the spindles. The dead centre can be mounted in ball bearing so that it rotates with the job avoiding friction of the job with dead centre as it important to hold heavy jobs.

Tail stock of central lathe.

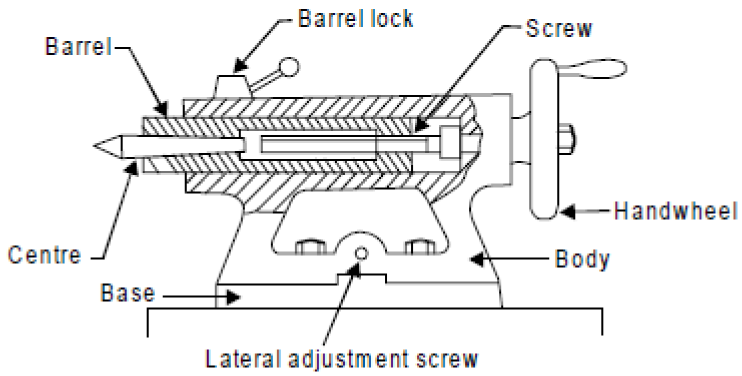


Figure 17: Parts of TailStock

5. Thread Cutting Mechanism

The half nut or split nut is used for thread cutting in a lathe. It engages or disengages the carriage with the lead screw so that the rotation of the leadscrew is used to traverse the tool along the workpiece to cut screw threads. The direction in which the carriage moves depends upon the position of the feed reverse lever on the headstock.

6. Feed Mechanism

Feed mechanism is the combination of different units through which motion of headstock spindle is transmitted to the carriage of lathe machine. Following units play role in feed mechanism of a lathe machine

- End of Bearing
- Feed gear box
- Lead screw and feed rod
- Apron mechanism

The gearing at the end of bed transmits the rotary motion of headstock spindle to the feed gear box. Through the feed gear box the motion is further transmitted either to the feed shaft or lead screw, depending on whether the lathe machine is being used for plain turning or screw cutting.
The feed gear box contains a number of different sizes of gears. The feed gear box provides a means to alter the rate of feed, and the ration between revolutions of the headstock spindle and the movement of carriage for thread cutting by changing the speed of rotation of the feed rod or lead screw.
The apron is fitted to the saddle. It contains gears and clutches to transmit motion from the feed rod to the carriage, and the half nut which engages with the lead screw during cutting threads.

- **Lead screw**

A lead screw is also known as a power screw or a translation screw. It converts rotational motion to linear motion. Lead Screw is used for Thread Cutting operation in a lathe machine tool.

- **Feed Rod**

Feed rod is used to move the carriage from the left side to the right side and also from the right side to the left side.

- **Main spindle**

The spindle is a hollow cylindrical shaft in which long jobs can pass through it.
It is designed so well that the thrust of the cutting tool does not deflect the spindle.

- **Leg**

Legs are carrying an entire load of a lathe machine tool and transfer to the ground. The legs are firmly secured to the floor by the foundation bolt.

L.O 2.2 Identify the tools

- **Content/Topic 1: Classification of Lathe Tools**

The tools which are used to for the purpose of cutting the materials in the desired shape and size are called cutting tool.
These cutting tools during cutting process produce waste materials in the form of chips or cutting. The cutting tools used to perform the cutting processes are either single point cutting tool or multi point cutting tools.

1. **Single point cutting:** when the cutting tool terminates into a single it is termed as single point tool. These tools are used on Lathe, shaper, Planer or Boring operation.
2. **Multipoint cutting tool:** when the cutting tools have more than one cutting edges it is termed as mulita point tool these tool are used on milling cutters, drill.

- **Classification of lathe tools According to the method of manufacturing of the tool**

a) Forged tool
b) Tipped tool brazed on carbon steel shank
c) Tipped tool fastened mechanically to the carbon steel shank

- **Forged tool** is generally stronger and more reliable than castings and plate steel due to the fact that the grain flows of the steel are altered, conforming to the shape of the part.

Forged tool has the following advantages:

• High temperature strength and good temper resistance to withstand hot wear and thermal fatigue cracking
• Good thermal conductivity to withstand thermal fatigue cracking
• Good hot ductility and toughness to resist initiation and rapid spread of thermal fatigue cracking

- **A tipped** tool is any cutting tool in which the cutting edge consists of a separate piece of material that is brazed, welded, or clamped onto a body made of another material. Common materials for the cutters (brazed tips or clamped inserts) include cemented carbide, polycrystalline diamond, and cubic boron nitride.

- **Tipped tool fastened mechanically to the carbon steel shank:** for this tool to ensure rigidity that a brazed tool does not offer, tips are sometimes clamped at the end of a tool shank by means of a clamp and bolt. Ceramic tips which are difficult to braze are clamped at the end of a shank mechanically fastened tipped tool.

❖ Classification of lathe tools According to the method of holding the tool

a) Solid tool
b) Tool bit inserted in the tool holder
c) Brazed tipped tool

Solid tool

Solid are made of high carbon steel forged and ground to the required shape. They are mounted directly on the tool post of a lathe.

Tool bit inserted in the tool holder

A tipped tool is any cutting tool in which the cutting edge consists of a separate piece of material that is brazed, welded, or clamped onto a body made of another material. In the types in which the cutter portion is an indexable part clamped by a screw, the cutters are called **inserts** (because they are inserted into the tool body). Tipped tools allow each part of the tool, the shank and the cutter(s), to be made of the material with the best properties for its job. Common materials for the cutters (brazed tips or clamped inserts) include cemented carbide, polycrystalline diamond, and cubic boron nitride. Tools that are commonly tipped include milling cutters (such as end mills, face mills, and fly cutters), tool bits, router bits, and saw blades (especially the metal-cutting ones).

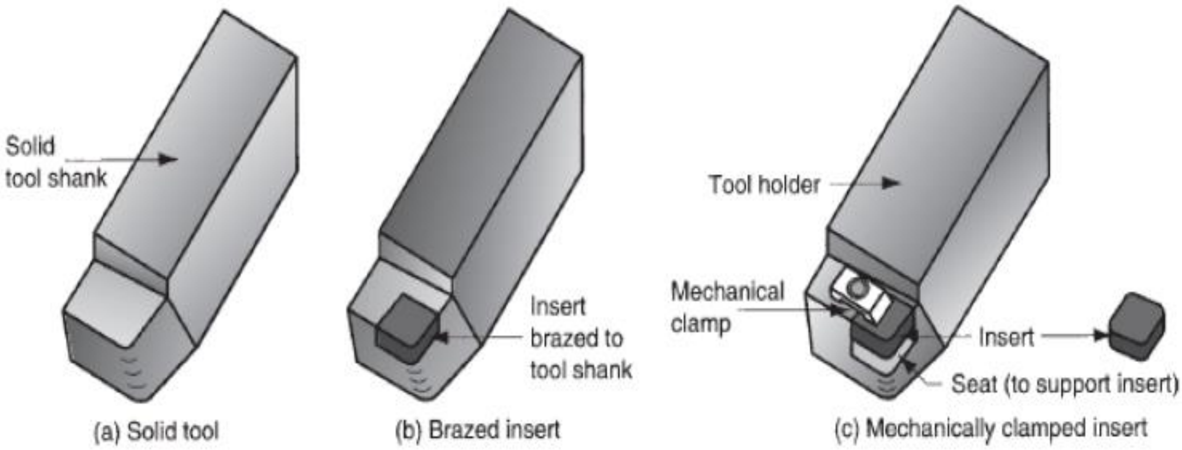


Figure 18: solid and tool bit inserted

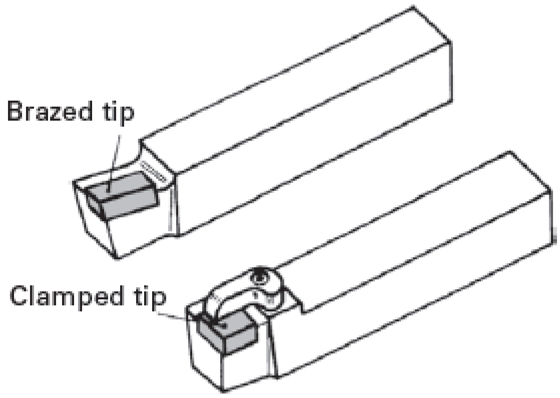


Figure 19: Tipped tool

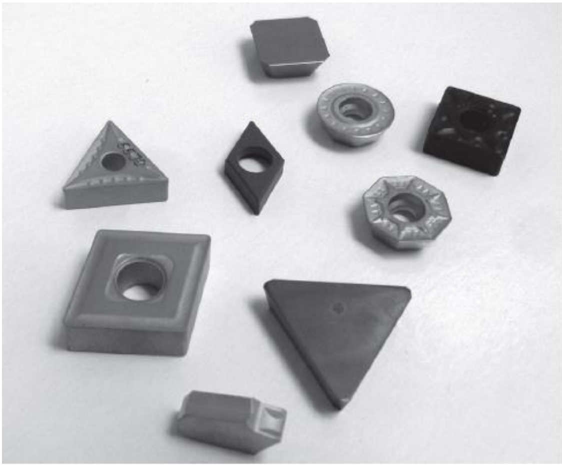
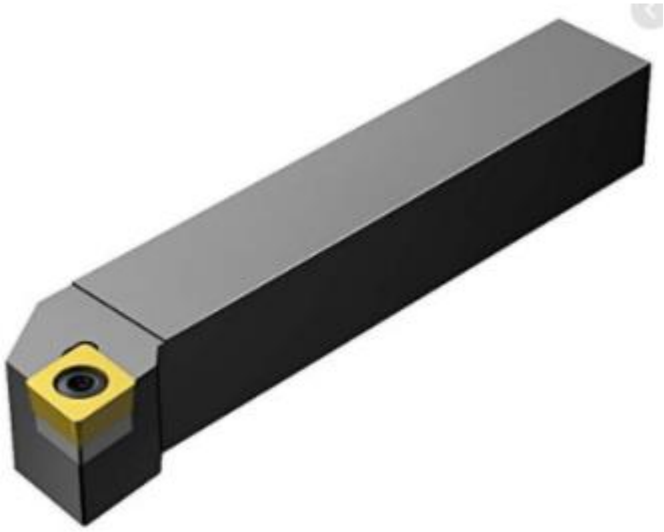


Figure 20: cutting tool inserts

- **Classification of lathe tools According to the method of use of the tool**
  1. Turning tool
  2. Thread cutting tool
  3. Facing tool
  4. Forming tool
  5. Parting tool
  6. Grooving tool
  7. Boring tool
  8. Internal thread cutting tool
  9. Knurling tool

a) Turning Tool

Lathe turning tool is a machine tool used principally for shaping pieces of metal, wood, or other materials by causing the workpiece to be held and rotated by the lathe while a tool bit is advanced into the work causing the cutting action.



b) Chamfering Tool

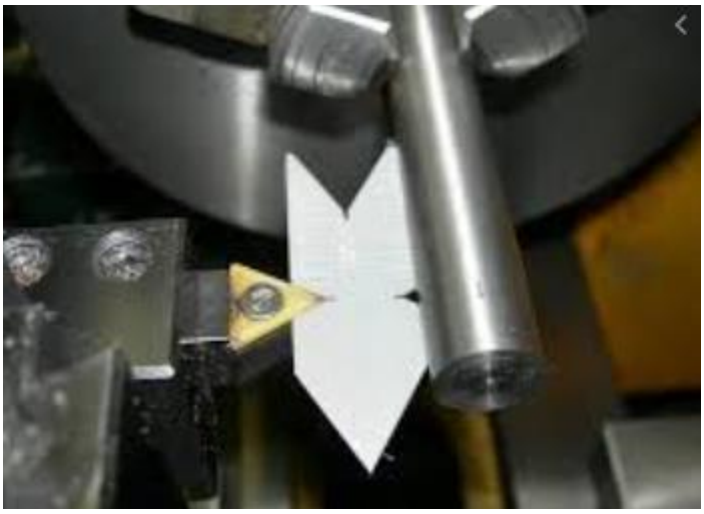
A Chamfer or deburring tool is used to create a bevel or furrow on the end of a bolt. The Unbar is a deburring tool that attached to the end of a drill to help mend the tip of a bolt.

c) Shoulder turning tool

It is a tool used when turning more than one diameter on a workpiece. The change in diameter or step. Frequently, it will be necessary to machine work that has two or more diameters in its length. The abrupt step, or meeting place, of the two diameters is called a shoulder. The workpiece may be mounted in a chuck, collet, or mandrel, or between centers as in straight turning.

d) External thread

It is a cutting tool used on lathe to produce external thread where this tool is shaped with 60^0 to the cutting edge.



e) Internal cutting thread

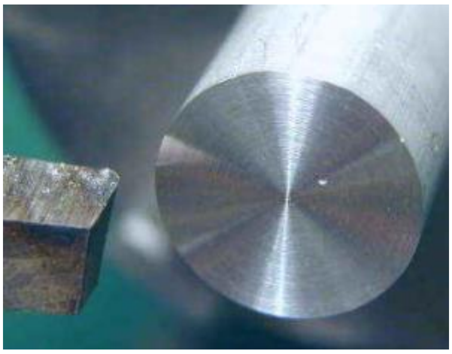
Internal Threading Tools are carbide threading tools, also called as lathe tools and are used as metal cutting tools in machine shops for a large variety of materials on Engine lathes, Chuckers, Turret lathes and Vertical Turret lathes.

Thread cutting on the lathe is a process that produces a helical ridge of uniform section on the workpiece. This is performed by taking successive cuts with a threading toolbit the same shape as the thread form required. Metric thread pitch is designated as the distance between threads (pitch) in millimeters. On an internal thread, the minor diameter occurs at the crests and the major diameter occurs at the roots.

.

f) Facing tool

Facing tool is a tool used to cut a flat surface perpendicular to the work piece's rotational axis. A facing tool is mounted into a tool holder that rests on the carriage of the lathe. The tool will then feed perpendicularly across the part's rotational axis as it spins in the jaws of the chuck.



g) Knurling Tool

The knurling tool consists of two cylindrical wheels, called knurls, which rotate in a specially designed tool holder. The knurls contain teeth which are rolled against the surface of the workpiece to form depressed patterns on the workpiece. The knurling tool accepts different pairs of knurls, each pair having a different pitch.

h) Drilling tool

A drill is a tool primarily used for making round holes or driving fasteners. It is fitted with a bit, either a drill or driver, depending on application, secured by a chuck.

The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute it is varying with different diameter according to the drill chuck to be fitted.

i) Reaming tool

Reaming tool is a rotary cutting tool of cylindrical or conical shape used for enlarging and finishing to accurate dimensions holes that have been drilled, bored, or cored. A reamer cannot be used to originate a hole.

j) Grooving & parting tool and cutting of tool

Grooving tool usually is a carbide insert mounted in a tool holder, can be used to cut external or internal grooves, and many other machining operations. There are multiple designs of grooving inserts, like a single tip or several tips for different configurations.

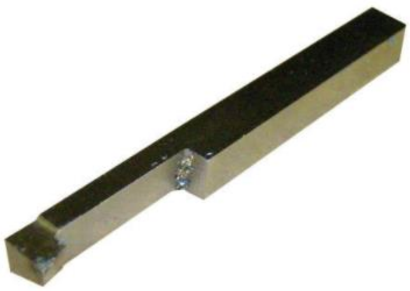
k) Forming tool

Straight and flat form tools have a square or rectangular cross-section with the form being along the side or end. These tools are similar in appearance to the turning tools. These are usually set centrally so that they will cut their contour which is identical to the desired contoured of the workpiece.

l) Boring tool

Boring tools are ground similar to left-hand turning cutter bits and thread cutter bits, but with more attention given to the end clearance angle to prevent the heel of the bit from rubbing against the surface of the bore. The boring cutter bit is clamped to a boring tool which in turn is supported in a boring tool holder that mounts to the lathe tool post.

A boring tool is used in the cutting of an inner surface diameter. It can make the hole, which has a big diameter, which is needed an accurate diameter, and which is needed a high surface roughness.



m) Counter boring tool

A counterbore tool is a cylindrical flat-bottomed hole that enlarges another coaxial hole, or the tool used to create that feature. A counterbore hole is typically used when a fastener, such as a socket head cap screw, is required to sit flush with or below the level of a workpiece's surface.

n) Undercutting tool

Undercutting tool usually is a carbide insert mounted in a tool holder, can be used to cut external or internal grooves, and many other machining operations. Grooving tools with more tips can reduce costs and improve productivity.

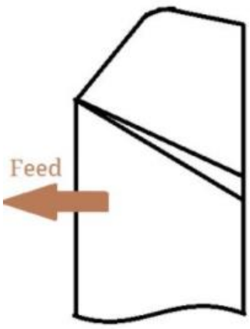
❖ **Classification of lathe tools According to the method of applying feed**

1. Right hand tool
2. Left hand tool
3. Round nose tool

a) Right Hand Turning Tool

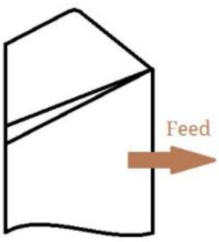
A right-hand cutting tool removes metal when moving from right to left. This is the most common turning activity, cutting towards the lathe chuck. The cutting edge is on the left side. Tools where the second letter is "R" are right-hand tools. Always cut with the point of the insert.
Right handed cutting tool

A right handed cutting tool, the common one, can remove material while moving leftward (take only top view keeping rake surface at top). The name is derived from its analogy with human right hand. As shown in the picture, the thumb direction represents the tool feed direction. Thus principal cutting edge of the tool must be at left side of the tool, as shown below.



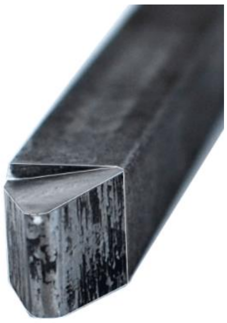
b) Left Handed Cutting Tool

Opposite to the right handed cutting tool, a left handed cutting tool can remove material while moving rightward (here also take only top view keeping rake surface visible). The name is derived from its analogy with human left hand as the left hand thumb direction indicates the tool feed direction. So the principal cutting edge should also be at the right side.



c) Round nose tool

Finishing tools have a rounded nose to provide a fine finish. These tools are for lighter turning. No side rake angle is ground into the top face when used to cut in either direction, but a tiny back rake angle might be required for chip removal. The nose radius is ground in the shape of a half-circle with a diameter of about 1/32 inch



(Left Hand Cutting Tool and Right Hand Cutting Tool (minaprem.com))

LO 2.3 Identify the lathe machine equipment

- **Content/Topic 1: Lathe Machine Accessories and Attachments**

Lathe Machine Accessories

There are many lathe accessories provided by the lathe manufacturer along with the lathe, which support the lathe operations. The important lathe accessories include centers, catch plates and carriers, chucks, collets, face plates, angle plates, mandrels, and rests. These are used either for holding and supporting the work or for holding the tool. Attachments are additional equipments provided by the lathe manufacturer along with the lathe, which can be used for specific operations. The lathe attachment include stops, ball turning rests, thread chasing dials, milling attachment, grinding attachment, gear cutting attachment, turret attachment and crank pin turning attachments and taper turning attachment.

a) Lathe centers

There are two basic types of centers, named live centers and dead centers. Firstly, a center that can accommodate a headstock spindle and also revolved with the work piece is called a live center. On the other hand, a dead center is used in a tailstock spindle and is not capable of revolving.
Lathe centers are the most common devices for supporting workpieces in a lathe. Most lathe centers have a tapered point with a 60^0 included angle to fit the workpiece holes with the same angle. The workpiece is supported between two centers, one in the headstock spindle and one in the tailstock spindle. Centers for lathe work have standard tapered shanks that fit into the tailstock directly and into the headstock spindle, using a center sleeve to convert the larger bore of the spindle to the smaller taper size of the lathe center.

The centers are referred to as live centers or dead centers, depending upon whether they move with the workpiece or remain stationary. The most common types of centers are described below.

Male Center: The male center or plain center is the type used in pairs for most general lathe turning operations. The point is ground to a 60° cone angle. When used in the headstock spindle, where it revolves with the workpiece, it is commonly called a live center. When used in the tailstock spindle, where it remains stationary when the workpiece is turning, it is called a dead center. Dead centers are always hard and must be lubricated very often to prevent overheating.
Pipe Center: The pipe center is very similar to the male center, but its cone is ground to a greater angle and is larger in size. It is used for holding pipe and tubing in the lathe while they are being machined.
Female Center: The female center is conically bored at the tip and is used to support workpieces that are pointed at the end.
Half-Male Center: The half-male center is a male center that has a portion of the 60° cone cut away. The half-male center is used as a dead center in the tailstock where complete facing is to be performed. The cutaway portion of the center faces the cutting tool and provides the necessary clearance for the tool when facing the surface immediately around the drilled center in the workpiece.

V-Center: The V-center is used to support round workpieces at right angles to the lathe axis for special operations such as drilling or reaming.

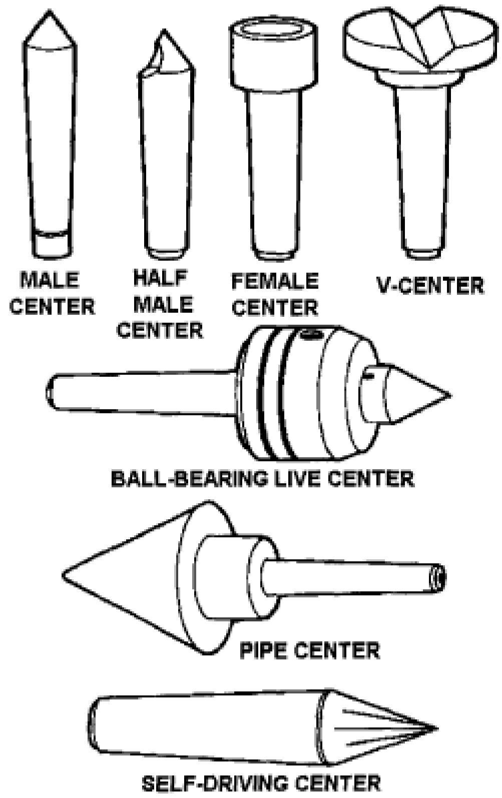


Figure 21: Lathe Center

b) Collet chuck

This type of chuck, fits on the spindle nose and is convenient for bar and the smaller diameter workpieces. Having fewer moving parts than the moving-jaw types makes it more accurate. It is more compact and does not have the same overhang from the spindle nose, and work can be machined up to the front of the collet. All-round gripping of the component makes it ideal for holding tube and thin-walled workpieces which tend to collapse in the three- or four-jaw chucks.

Figure 22: collet Chuck

Multi-size collet

c) Carriers or driving dog and catch plates

These are used to drive a job when it is held between two centers. Carriers or driving dogs are attached to the end of the job by a setscrew. A use of lathe dog for holding and supporting the job. Catch plates are either screwed or bolted to the nose of the headstock spindle. A projecting pin from the catch plate or carrier fits into the slot provided in either of them. This imparts a positive drive between the lathe spindle and job.

Carriers are also known as driving dogs and used to drive the workpiece when it is held between two centres. These are attached to the end of the workpiece by a set screw. Catch plates are either screwed or bolted to the nose of the threaded, stock spindle.

A projecting pin from the dog fits into the slot provided in catch plate. This imparts a positive drive between the lathe spindle and workpiece.

d) Chucks

Chuck is one of the most important devices for holding and rotating a job in a lathe. It is basically attached to the headstock spindle of the lathe. The internal threads in the chuck fit on to the external threads on the spindle nose. Short, cylindrical, hol1ow objects or those of irregular shapes, which cannot be conveniently mounted between centers, are easily and rigidly held in a chuck. Jobs of short length and large diameter or of irregular shape, which cannot be conveniently mounted between centers, are held quickly and rigidly in a chuck.

There are a number of types of lathe chucks, e.g.
(1) Three jaws or universal
(2) Four jaw independent chuck
(3) Magnetic chuck
(4) Collet chuck
(5) Air or hydraulic chuck operated chuck
(6) Combination chuck
(7) Drill chuck.
A lathe chuck is a device that exerts pressure on the workpiece to hold it secure to the headstock spindle or tailstock spindle. Commonly used with the lathe are the independent chuck, the universal scroll chuck, the combination chuck, the hollow headstock spindle chuck, the lathe tailstock chuck, the collet chuck, and the step chuck.

- **Independent Chuck or four jaws independent chuck**

The independent chuck generally has four jaws which are adjusted individually on the chuck face by means of adjusting screws. The chuck face is scribed with concentric circles which are used for rough alignment of the jaws when chucking round workpieces. The final adjustment is made by turning the workpiece slowly and using gages to determine its concentricity. The jaws are then readjusted as necessary to align the workpiece to desired tolerances.

Four-jaw independent chuck

- **Universal Scroll Chuck or Three jaws**

A pinion engaging in a gear on the front of which is a scroll, all encased in the chuck body. The chuck jaws, which are numbered and must be inserted in the correct order, have teeth which engage in the scroll and are guided in a slot in the face of the chuck body. As the pinion is rotated by a chuck key, the scroll rotates, causing all three jaws to move simultaneously and automatically centre the work.
The universal scroll chuck can be used to hold and automatically center round or hexagonal workpieces. Having only three jaws, the chuck cannot be used effectively to hold square, octagonal, or irregular shapes.

- **Combination Chuck**

A combination chuck combines the features of the independent chuck and the universal scroll chuck and can have either three or four jaws. The jaws can be moved in unison on a scroll for automatic centering or can be moved individually if desired by separate adjusting screws.

- **Drill Chuck**

The drill chuck is a small universal-type chuck which can be used in either the headstock spindle or in the tailstock for holding straight-shank drills, reamers, taps, or small-diameter workpieces. The drill chuck has three or four hardened steel jaws which are moved together or apart by adjusting a tapered sleeve within which they are contained.

- **Hollow Headstock Spindle Chuck**

The hollow headstock spindle chuck is similar to a drill chuck but is hollow. It is provided with threads to screw it onto the headstock spindle nose. This chuck can be used to hold rods, tubes, or bars which are passed through the headstock spindle. It is generally capable of centering workpieces to an accuracy of 0.002 of an inch.

- **Step Chuck**

The step chuck is a variation of the collet chuck, but is intended for accurate holding of workpieces larger than 1 inch in diameter.
The step chuck consists of the handwheel or hand lever collet attachment and a step chuck machine collet in place of the regular spring machine collet.
The step chuck machine collet, which is split into three sections like the spring machine collet, is threaded to the draw bar of the collet attachment.
The step chuck machine collets are furnished blank and machined on the lathe to the desired step diameter.

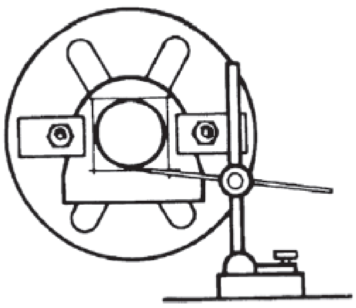
- **Lathe Tailstock Chuck**

The lathe tailstock chuck is a device designed to support the ends of the workpieces in the tailstock when a lathe center cannot be conveniently used. The chuck has a taper arbor that fits the lathe tailstock spindle. The three bronze self-centering jaws of the chuck will accurately close upon the workpieces that are between 1/4 and 1 inch in diameter. The bronze jaws provide a good bearing surface for the workpiece. The jaws are adjusted to the diameter of the workpiece and then locked in place.

e) Face plates

Face plates are employed for holding jobs, which cannot be conveniently held between centers or by chucks. A face plate possesses the radial, plain and T slots for holding jobs or work-pieces by bolts and clamps. Face plates consist of a circular disc bored out and threaded to fit the nose of the lathe spindle. They are heavily constructed and have strong thick ribs on the back. They have slots cut into them, therefore nuts, bolts, clamps and angles are used to hold the jobs on the face plate. They are accurately machined and ground.
A small faceplate, known as a driving faceplate, is used to drive the lathe dog for workpieces mounted between centers. The driving faceplate usually has fewer T-slots than the larger faceplates. When the workpiece is supported between centers, a lathe dog is fastened to the workpiece and engaged in a slot of the driving faceplate.

Figure 23: Face Plate



Setting workpiece on a faceplate

Precautions for faceplate work

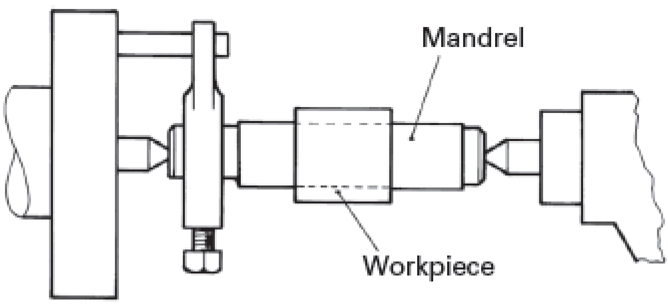
When the workpiece has been clamped, check each nut and screw to ensure it is tight. Turn the faceplate by hand and check that all bolts and clamps are clear of the bed, cross-slide or toolpost. To ensure this, avoid using excessively long clamping bolts. Check for 'out of balance' of the faceplate – a counterbalance may be required.

f) Angle plates

Angle plate is a cast iron plate having two faces machined to make them absolutely at right angles to each other. Holes and slots are provided on both faces so that it may be clamped on a faceplate and can hold the job or workpiece on the other face by bolts and clamps. The plates are used in conjunction with a face plate when the holding surface of the job should be kept horizontal.

g) Mandrels

Work which has a finished bore and requires the outside to be turned concentric to it can be mounted on a mandrel. The mandrel is then put between centres and the work is machined as already described for 'between-centres' work.
The diameter is tapered over its length, usually about 0.25 mm for every 150 mm length. When the work is pushed on, this slight taper is enough to hold and drive the work during the machining operation.
A mandrel is a device used for holding and rotating a hollow job that has been previously drilled or bored. The job revolves with the mandrel, which is mounted between two centers.
It is rotated by the lathe dog and the catch plate and it drives the work by friction. Different types of mandrels are employed according to specific requirements. It is hardened and tempered steel shaft or bar with 60° centers, so that it can be mounted between centers. It holds and locates a part from its center hole. The mandrel is always rotated with the help of a lathe dog; it is never placed in a chuck for turning the job. A mandrel unlike an arbor is a job holding device rather than a cutting tool holder. A bush can be faced and turned by holding the same on a mandrel between centers. It is generally used in order to machine the entire length of a hollow job.



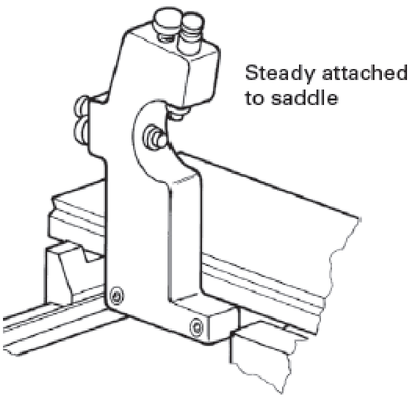
h) Rests

A rest is a lathe device, which supports a long slender job, when it is turned between centers or by a chuck, at some intermediate point to prevent bending of the job due to its own weight and vibration set up due to the cutting force that acts on it. The two types of rests commonly used for supporting a long job in an engine lathe are the steady or centre rest and the follower rest.

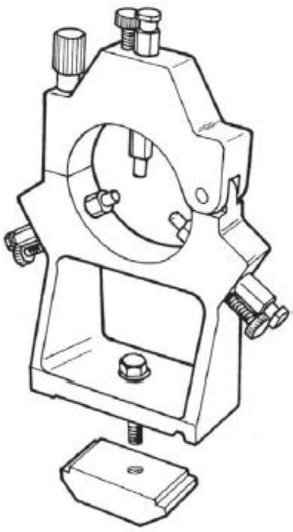
Steady Rest

The steady rest or center rest, as it is also called is used to support long workpieces or shafts being machined between centers or for boring operations. It is also used for internal threading operations where

the workpiece projects a considerable distance from the chuck or faceplate. The steady rest is clamped to the lathe bed at the desired location and supports the workpiece within three adjustable jaws. The rest prevents the workpiece from springing under cut, or sagging as a result of the otherwise unsupported weight.
The workpiece must be machined with a concentric bearing surface at the point where the steady rest is to be applied. The jaws must be carefully adjusted for proper alignment and locked in position. The area of contact must be lubricated frequently. The top section of the steady rest swings away from the bottom section to permit removal of the workpiece without disturbing the jaw setting.



Two-point travelling steady


Three-point fixed steady

Follower Rest
The follower rest is used to back up a workpiece of small diameter to keep it from springing under the stress of the cutting operation. The follower rest gets its name because it follows the cutting tool along the workpiece. The follower rest has one or two jaws that bear directly on the finished diameter of the workpiece opposite and above the cutting tool. The rest is bolted to the lathe carriage so that it will follow the cutter bit and bear upon that portion of the workpiece that has just been turned. The cut must be started and continued for a short longitudinal distance before the follower rest is applied. The rest is generally used only for straight turning or threading long, thin workpieces.

i) **Lathe Dogs**
Lathe dogs are cast metal devices used in conjunction with a driving plate or a faceplate to provide a firm connection between the headstock spindle and the workpiece that is mounted between centers. This firm connection permits the workpiece to be driven at the same speed as the spindle under the strain of cutting. Frictional contact alone, between the live center and the workpiece, is not sufficient to drive the

workpiece. Lathe dogs may have bent tails or straight tails. When the bent tail dogs are used, the tail fits into a slot of the driving face plate. When straight tail dogs are used, the tail bears against a stud projecting from the faceplate.

The bent tail lathe dog with a headless setscrew is considered safer than the dog with the square head screw because the headless setscrew reduces the danger of the dog catching in the operator's clothing and causing an accident.

The bent tail clamp lathe dog is used primarily for holding rectangular workpieces.

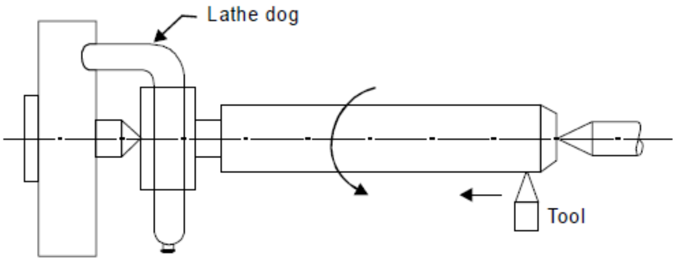


Figure 24: use of Lathe god

Three common lathe dogs are illustrated in Figure below, Lathe dogs may have bent tails or straight tails. When bent-tail dogs are used, the tail fits into a slot of the driving faceplate. When straight-tail dogs are used, the tail bears against a stud projecting from the faceplate. The bent tail lathe dog with headless setscrew is considered safer than the dog with the square head screw because the headless setscrew reduces the danger of the dog catching in the operator's clothing and causing an accident. The bent-tail clamp lathe dog is used primarily for rectangular workplaces.

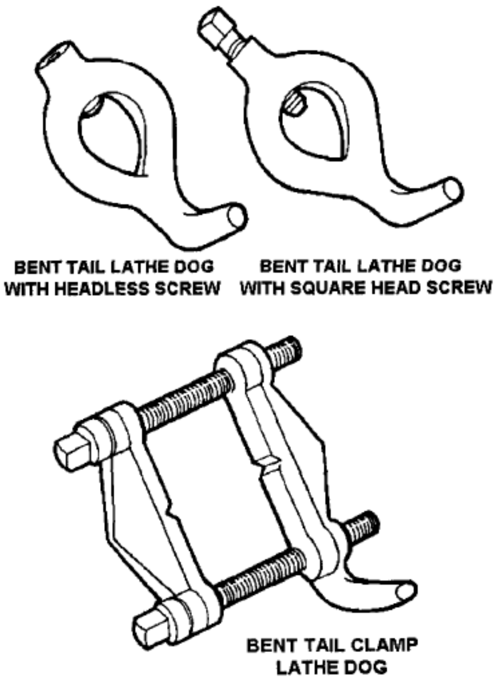


Figure 25: Lathe Dog

Lathe Attachment

a) Taper Attachment

The taper attachment is used for turning and boring tapers. It is bolted to the back of the carriage saddle. In operation, it is connected to the cross-slide so that it moves the cross-slide laterally as the carriage moves longitudinally. This action causes the cutting tool to move at an angle to the axis of the workpiece to produce a taper.

The angle of the desired taper is set on the guide bar of the attachment, and the guide bar support is clamped to the lathe bed. Since the cross-slide is connected to a shoe that slides on this guide bar, the tool follows along a line that is parallel to the guide bar and hence at an angle to the workpiece axis corresponding to the desired taper.

Taper-turning attachments can be fitted at the rear of the cross-slide and can be used to turn included angles up to 20 over a length of around 250 mm, both internally and externally.

The guide bar, which swivels about its centre, is mounted on a base plate which carries the graduations. The base plate is attached to the connecting rod, which passes through a hole in the clamp bracket where it is held tightly by a clamping screw. The clamp bracket is clamped to the bed of the machine. Thus the guide bar, base plate, connecting rod and clamp bracket are securely fixed to each other and to the machine bed.

A plan view of a typical taper-turning attachment is shown in the figure below:

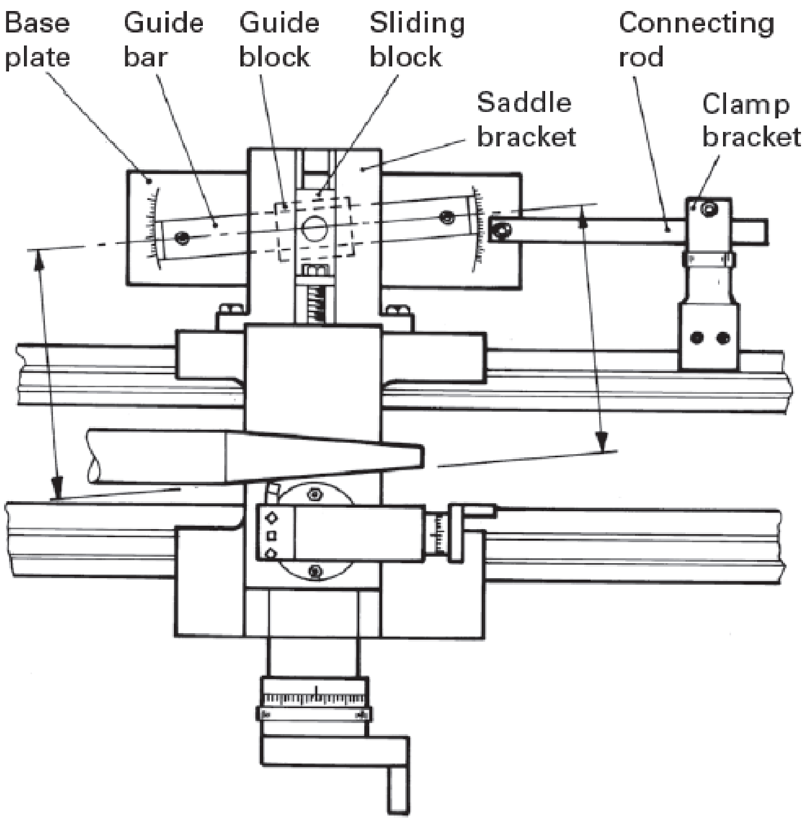


Figure 26: taper-turning attachment

b) Milling Attachment for Lathe

These attachments are used to make helical grooves, flat surfaces, deep screw threads, worms, helical grooves, keyway cutting, Tee Slot cutting, thread milling, etc. The milling attachment is generally fixed in the place of the Compound rest of the lathe machine.

It generally consists of a milling head and a spindle to hold the milling cutter which is mounted on the milling attachment. It consists of a motor that can act as a driving mechanism in the milling machine.

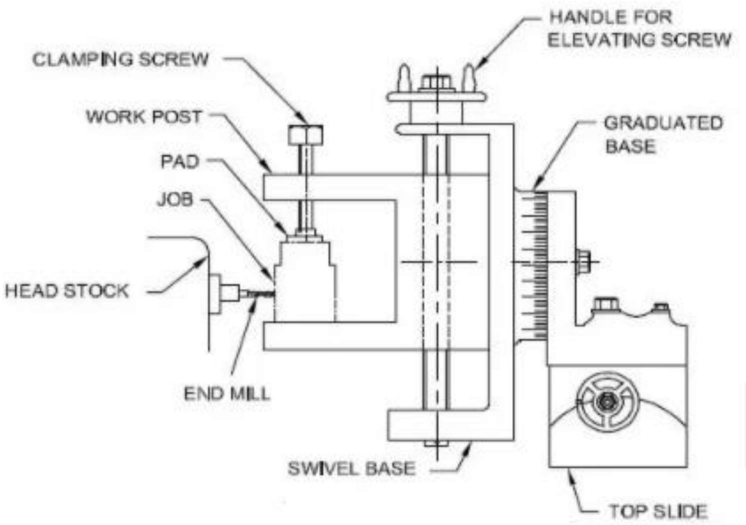


Figure 27: milling attachment

(Black, 2003)

Learning Unit 3: Select machine, equipment, tools and materials Configure

LO 3.1 select the machine

- **Content/Topic 1: Lathe Machine Specifications**

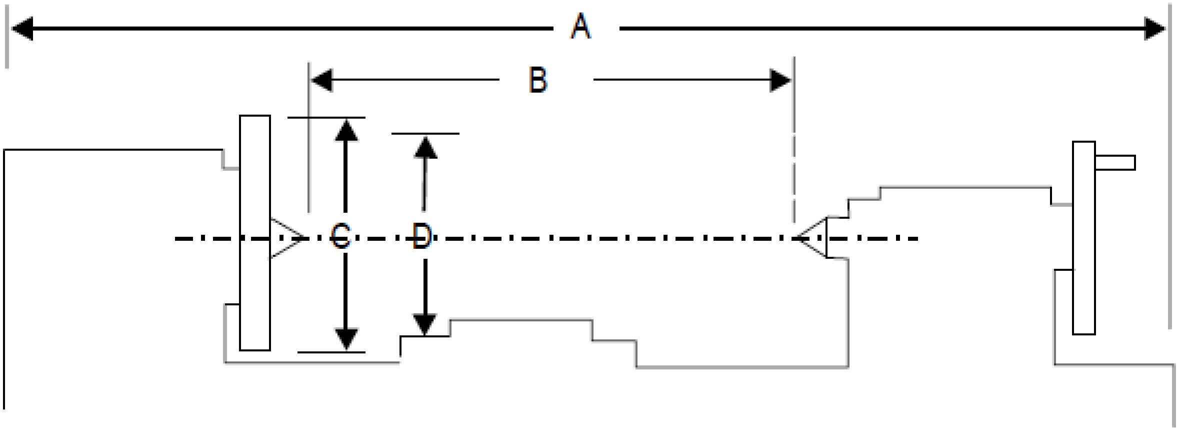
The size of a lathe is generally specified by the following means:

1. The length of the bed
2. Maximum distance between live and dead centres.
3. The height of centres from the bed
4. The swing diameter
5. Length between centers

The swing diameter over bed - It refers to the largest diameter of the work that will be rotated without touching the bed

The swing diameter over carriage - It is the largest diameter of the work that will revolve over the saddle.

6. Diameter of hole through spindle
7. The width of the bed
8. The type of the bed
9. Pitch value of the lead screw
10. Power of the motor or power input
11. Number of spindle speeds
12. Floor space required
13. Lead screw diameter and number of threads per cm.
14. Morse taper of center
15. Face plate diameter
16. Size of tool post
17. Pitch range of metric and inch threads etc.



A - Length of bed.
B - Distance between centres.
C - Diameter of the work that can be turned over the ways.
D - Diameter of the work that can be turned over the cross slide.

Figure 28: Lathe Machine Specification

LO 3.2 select the tools and equipment

- **Content/Topic 1 Elements to consider when selecting Lathe Tool and Equipment**

a) Machining parameters

The following terms are commonly used while machining a work piece on lathe.

- **Cutting speed:** It is defined as the speed at which the metal is removed by the tool from the work piece. In other words, it is the peripheral speed of the work past the cutting tool. It is usually expressed in meters per minute.

Spindle speed (N) = $\frac{V}{\pi D0}$ **(rpm)**

Where:

N: Spindle speed

V: Cutting speed

D_0: Outer Diameter

- **Feed:** It is defined as the distance which the tool advances for each revolution of the work.

It is usually expressed in millimeters.

- **Depth of cut:** It is defined as the depth of penetration of the tool into the work piece during machining. In other words, it is the perpendicular distance measured from the machined surface to the unmachined surface of the work piece. It is usually expressed in millimeters.

  d = $\frac{D0-Df}{2}$ mm/rev

- **Feed rate** is the velocity at which the cutter is fed, that is, advanced against the workpiece. It is expressed in units of distance per revolution for turning and boring (typically inches per revolution or millimeters per revolution).

Feed rate: **Fr= N*f* *(mm/min)***

F= feed per rev

b) Types of turning operations

For performing the various machining operations in a lathe, the job is being supported and driven by anyone of the following methods.

1. Job is held and driven by chuck with the other end supported on the tail stock centre.
2. Job is held between centers and driven by carriers and catch plates.
3. Job is held on a mandrel, which is supported between centers and driven by carriers and catch plates.
4. Job is held and driven by a chuck or a faceplate or an angle plate.

The above methods for holding the job can be classified under two headings namely job held between centers and job held by a chuck or any other fixture. The operations performed in a lathe can be understood by three major categories:

(a) Operations, which can be performed in a lathe either by holding the workpiece between centers or by a chuck are:

- Straight turning
- Shoulder turning
- Taper turning
- Chamfering
- Eccentric turning
- Thread cutting
- Facing
- Forming
- Filing
- Polishing
- Grooving
- Knurling
- Spinning
- Spring winding

(*b*) Operations which are performed by holding the work by a chuck or a faceplate or an angle plate are:

- knurling
- facing
- Parting-off
- Drilling
- reaming
- boring
- Internal thread cutting
- Counter boring
- Taper boring
- Tapping

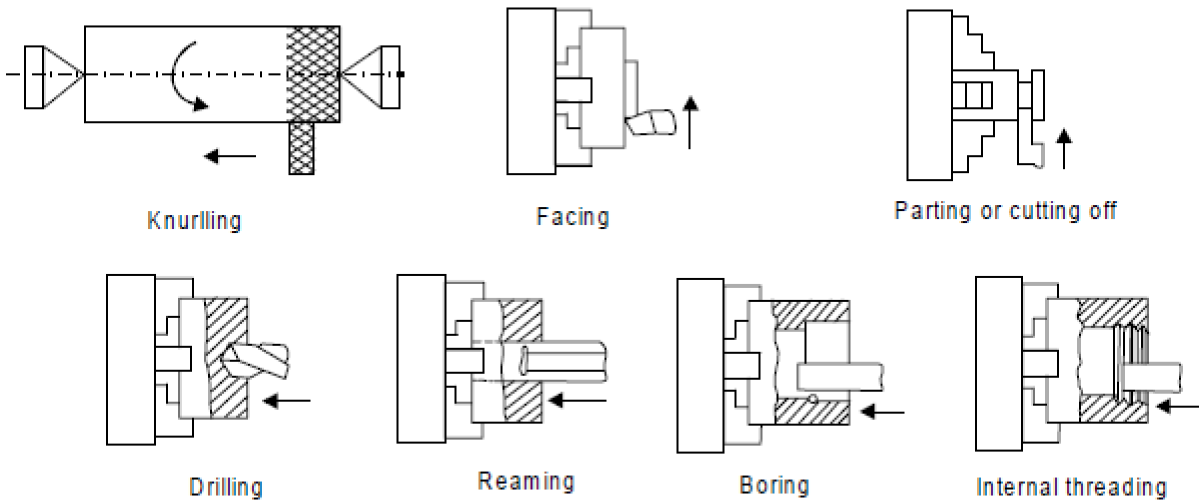


Figure 29: Lathe Operations

(*c*) Operations which are performed by using special lathe attachments are:

- Milling
- Grinding

c) Cutting tool materials

The most important factor in cutting tool efficiency is the material from which the tool is made. Correct design and accurate rake and clearance angles amount to nothing if the tool material is unable to stand up to the cutting conditions. All cutting tool materials must possess the following two properties.

i. Hardness

ii. Toughness

The approximate temperature of a metal chip sheared by a cutting tool under conditions of efficient machinery is 500°C, although the use of lubricant and coolants may reduce the temperature.

The common types of cutting tool materials available include:

i. High Carbon Steel

This has a relatively high carbon content which means that it has low hardness fig at 500°C. This steel loses hardness rapidly when it is taken to temperatures in excess of 220°C. At 350°C to be precise the steel has almost reverted to its normal hardness value. This is a serious limitation on the one of HCS as a cutting tool material.

Carbon steel, or tool steel is high in carbon content, hardens to a high degree of hardness when properly heated and quenched. The carbon-steel tool will give good results as long as constant care is taken to avoid overheating or "bluing," since the steel will lose its temper or hardness at a relatively low heat becoming ineffective as a cutting tool.

For low-speed turning, high carbon steels give satisfactory results and are more economical than other materials.

ii. High-Speed Steel(HSS)

The hardness of this steel increases between 400°C and 550°C. This is quite unlike the behavior of HCS and it is clear that the friction involved when machining at high speeds will not affect the hardness values of hardened HSS. HSS possess the quality of red hardness; that is to say it has ability to retain its hardness value even when the swart is leaving the parent metal at red heat.
This steel is a very expensive metal (steel), simply put its cost is ten times the cost of HCS. It is used in the production of cutting tools like, drills, reamers, and milling cutters. Due to its high cost it is sometimes welded to cheaper and triangular material if the need arises, thus providing not only cheaper tool but also one that is more likely to stand up to cutting conditions.
High-speed steel is alloyed with tungsten and sometimes with chromium, vanadium, or molybdenum. Although not as hard as properly tempered carbon steel, the majority of lathe cutting tools are made of high-speed steel because it retains its hardness at extremely high temperatures. Cutter hits made of this material can be used without damage at speeds and feeds which heat the cutting edges to a dull red.

iii. Stellite

Stellite is the trade name of a special material. It is a nonferrous alloy containing high proportion of cobalt, chromium and tungsten. It is harder than HSS. When poured in liquid state from an electric furnace satellite is self-hardening, thus a satellite carting allowed to cool in air has a Rockwell hardness value of 62 on the C scale.
This inherent hardening property allows the use of satellite as a hard facing metal, available for electrodes to be used in arc welding process.
Satellite is used as inserts for large diameter milling cutter, this is much better proposition than milling a large diameter milling cutter from HSS. Apart from the high cost of solid high speed milling cutter, there is a considerable with of cracking or distortion during heat treatment process, not to mention the possibility of tool breakage when in use. The inserted tool type milling cutter using stellite teeth is an efficient and reliable multi-point cutting tool, the high tensile strength of stellite allows the inserted blades to stand up to the considerable stress involved.
These cutter bits will withstand higher cutting speeds than high-speed steel cutter bits. Stellite is a nonmagnetic alloy which is harder than common high-speed steel. The tool will not lose its temper, even though heated red hot from the friction that is generated by taking a cut. Stellite is more brittle than high-speed steel. To prevent breaking or chipping, it requires just enough clearance to permit the tool to cut freely. Stellite is also used for machining hardened steel, cast iron, bronze, etc.

iv. Cemented Or Tungsten Carbides

This is an unexceptionally hard material, it is however brittle as such it is being used as a tip, necessary segmented and brazed to a Carbon steel shank and employed as a lathe tools. It can be alloyed with elements like tantalum and titanium which gives it excellent steel cutting properties and a long tool life.
Tungsten carbide is used to tip cutter bits when maximum speed and efficiency is required for materials which are difficult to machine. Although expensive, these cutter bits are highly efficient for machining cast iron, alloyed cast iron, copper, brass, bronze, aluminum,

Babbitt metal, and such abrasive nonmetallic materials as fiber, hard rubber, and bakelite. Cutter bits of this type require very rigid support and are usually held in open-side toolposts. They require special grinding wheels for sharpening, since tungsten carbide is too hard to be redressed on ordinary grinding abrasive wheels.

v. Ceramics

Ceramics possess a higher hardness value than tungsten carbon at a temperature of 500°C, but it is more brittle. It is chemically inert, with a low coefficient of friction and low heat conductivity, a ceramic tipped tool has very high metal removal rate, together with the ability to produce a good finish. The life of a ceramic tipped tool is high even when working at maximum speeds and produces surfaces with very close dimensional tolerance.

vi. Diamond

Tools tipped with diamond are used for high grades machinery of hard metals and often plastics which blunt H.S.S. tools very quickly. For preparation of diamond tools, selected brown and black diamonds are cut and lapped to a suitable shape and mounted in holders. Diamonds tools accommodate cutting speeds up to 300 m/min and under ideal conditions the tool will give very long life. The figure below show Throw away tipped Cutting tool holders

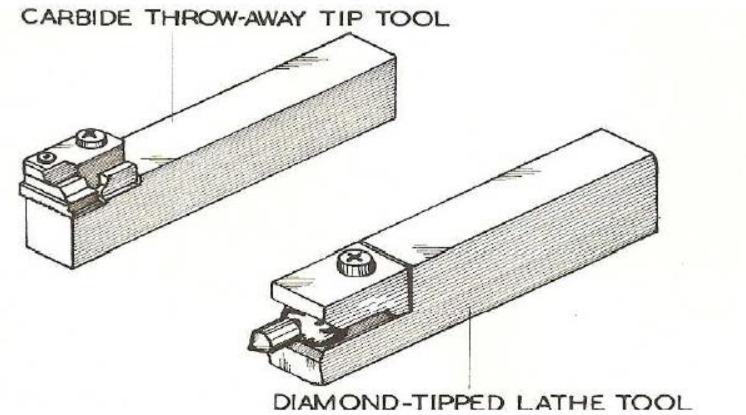


Figure 30: Diamond Cutting Tool

vii. Abrasive

An abrasive is a material, often a mineral, that is used to shape or finish a workpiece through rubbing which leads to part of the workpiece being worn away by friction.

Factors affecting tool life

The life of the cutting tool is affected by the following factors:

- Cutting speed.
- Feed and depth of cut.
- Tool geometry.
- Tool material.
- Cutting fluid.
- Work piece material.
- Rigidity of work, tool and machine.

d) Work mounting techniques on the lathe machine

The job or blank and the cutting tools essentially need to be properly mounted in the machine tool for achieving desired performance of the machining system.
The following principles are generally followed and conditions are maintained;

❖ **while mounting the job or blank in the machine tool**

- Appropriate selection of work holding device or system from the available resources depending upon;
  - ✓ configuration of the machine tool
  - ✓ shape, size and weight of the blank
  - ✓ kind of machining work to be done
  - ✓ order of dimensional accuracy desired
  - ✓ volume (number of same job) of production
- Correct location, strong support and rigid clamping of the blank against the cutting and other forces
- Easy and quick loading and unloading to and from the machine tool or the holding device
- Proper alignment like coaxially, concentricity etc. of rotating jobs
- free flow of chips and cutting fluid

❖ **while mounting the cutting tools**

- Appropriate selection of tool holder and the method of mounting
- Proper positioning and orientation of the tool depending upon its
  - ✓ type
  - ✓ size and shape
  - ✓ geometry
- proper alignment in respect of coaxiality, concentricity and machine tool configuration
- accurate and quick locating, strong support and rigid clamping
- minimization of run out and deflection during cutting operation
- easy and quick mounting and change
- Unobstructed chip flow and cutting fluid action.

LO 3.3 Select materials

- **Content/Topic 1: Work Material Properties**

The knowledge of materials and their properties is of great significance for a design. The machine elements should be made of such a material which has properties suitable for the conditions of operation. In addition to this, a design Technician must be familiar with the effects which the manufacturing processes and heat treatment have on the properties of the materials.
The following are some of materials properties:

1. **Hardness.** It is a very important property of the metals and has a wide variety of meanings. It embraces many different properties such as resistance to wear, scratching, deformation and machinability etc. It also means the ability of a metal to cut another metal.

The hardness is usually expressed in numbers which are dependent on the method of making the test. The hardness of a metal may be determined by the following tests:

- Brinell hardness test,
- Rockwell hardness test,
- Vickers hardness (also called Diamond Pyramid) test, and
- Shore scleroscope.

2. **Machinability.** It is the property of a material which refers to a relative case with which a material can be cut. The machinability of a material can be measured in a number of ways such as comparing the tool life for cutting different materials or thrust required to remove the material at some given rate or the energy required to remove a unit volume of the material. It may be noted that brass can be easily machined than steel.
3. **Toughness.** It is the property of a material to resist fracture due to high impact loads like hammer blows. The toughness of the material decreases when it is heated. It is measured by the amount of energy that a unit volume of the material has absorbed after being stressed up to the point of fracture. This property is desirable in parts subjected to shock and impact loads.
4. **Brittleness.** It is the property of a material opposite to ductility. It is the property of breaking of a material with little permanent distortion. Brittle materials when subjected to tensile loads, snap off without giving any sensible elongation. Cast iron is a brittle material.
5. **Castability**: is defined as the property of metal, which indicates the ease with it can be casted into different shapes and sizes. Cast iron, aluminium and brass are possessing good castability.
6. **Weldability** is defined as the property of a metal which indicates the two similar or dissimilar metals are joined by fusion with or without the application of pressure and with or without the use of filler metal (welding) efficiently. Metals having weldability in the descending order are iron, steel, cast steels and stainless steels.

Learning Unit 4: Perform sharpening cutting tool

LO 4.1 Mount the grinding wheel

- **Content/Topic 1- Factors Influencing the Selection of grinding Wheel**

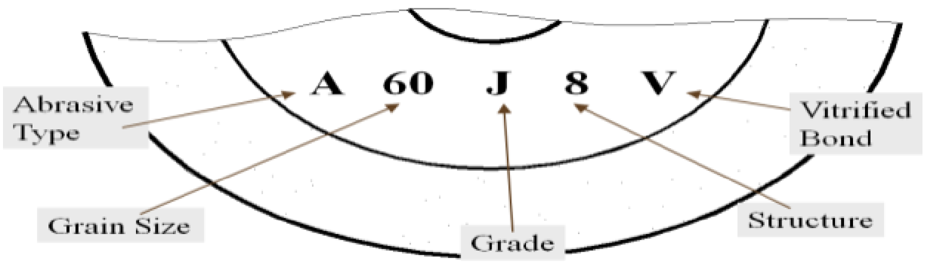
Grinding machine is one type of machine tool with economical to produce a smooth.
Machine tool with multi-eye cut is widely used to sharpen/cut workpiece with a specific purpose.
The working principle of the grinding machine is the rotation of the grinding wheel in contact with the workpiece resulting in the erosion, sharpening, grinding, or cutting on the workpiece.
The following are the factors influencing the selection of grinding wheel:

a) Abrasive grain
b) Grain size Wheel grade

c) Grain spacing
d) Wheel bond

The process of grinding is dependent upon the following:

- Type of **abrasive** used in the wheel
- **Size** and distribution of **grit** in the wheel
- Amount and type of **bonding** material
- **Volume of porosity**: relative to abrasive and bonding material.



First Symbol: Type of Abrasive

A wheel marked A 60-J8V indicates the following:

A – Fused aluminum oxide

Second Symbol: Grit Size

The following scale can be used to determine grit:

4	36	46	60	100	120	240	500
	Coarse			*Medium*		*Fine*	

Third Symbol: Grade of Hardness

- Hardness grade is a measure of bond strength of the grinding wheel.
  - ✓ Bond material holds abrasive grains together in the wheel.
  - ✓ The stronger the bond, the harder the wheel.
- Hardness grade is a measure of bond strength of the grinding wheel.

A to G are softer.

H to P are more medium grades.

R to Z are harder.

Fourth Symbol: Structure

Structure, the spacing of the abrasive grains in the wheel is indicated by numbers.

1 is a dense structure.

8 is a more medium structure.

15 is an open structure.

Fifth Symbol: Bond

Bond is identified by letter according to the following:

- ✓ V – Vitrified
- ✓ B – Resinoid
- ✓ R – Rubber
- ✓ E – Shellac
- ✓ M – Metal

GRINDING WHEEL

Grinding wheel is a multipoint cutting tool having abrasive particles bonded together and so forming a structure.

Two types of material is used for wheel:

a) Natural abrasives

Natural abrasives include sand stone, diamond, corundum and emery. Diamond abrasive wheels are used sharpening carbide and ceramic cutting tools. They are also used for turning and dressing other types of abrasive wheels. The principal component of corundum and emery is natural aluminum oxide (alumina). Corundum is composed of about 85% aluminum oxide and 75 % iron oxide. Emery contains (10%, aluminum oxide and 40% iron oxide).

b) Artificial abrasives:

They include silicon carbide and aluminum oxide. Silicon carbide is made by heating silica sand, coke, salt and sawdust in an electric furnace at 2300^0C for hours resulting in a solid mass of silicon carbide. Aluminum oxide abrasive is the crystalline form of aluminum oxide.

Grinding wheels are made in different shapes and sizes to adapt them for use in different types of grinding machines and on different classes of work. The shapes of grinding wheels are standardized so that those commonly used in production and tool room grinding may be designated by a number or name or both. Some of the standard grinding wheels are shown below.

Size of a Grinding Wheel

Major dimensions of a grinding wheel are the outside diameter; bore diameter; and width of the face. In addition to the above geometry of the face of grinding wheel also matters. It may be flat, pointed, concave, convex, etc.

THE FOLLOWING ARE FACTORS INFLUENCING THE SELECTION OF GRINDING WHEEL

1. Abrasive Grain Size selection

The selection of abrasive grain size required depends upon the following factors:

1. Amount of material to be removed
2. Finish desired
3. Hardness of material being ground

The coarse grit is used for more material removal whereas the fine grit is used for small material removal rate. Sizes from 240 to 600 are used for lapping and honing applications.

Fin and very fine grain size is used for precision grinding, however, coarse and medium grain size is used for rough grinding.

The various numbers for different types of grain size are given below:

Coarse grain: 8, 10, 12, 14, 16, 24
Medium grain: 30, 36, 46, 54, 60
Fine grain: 80, 100, 120, 150,180
Very fine grain: 220, 240, 280, 320, 400,500,600.
For all types of grinding higher limit is upto 180. The grit number above 200 is recommended for lapping operation etc.

Class	**Grain Size of Abrasive** (Grit)						
Coarse	10	12	14	16	20	24	
Medium	30	36	46	54	60		
Fine	80	100	120	150	180		
Very fine	220	240	280	320	400	500	600

2. Wheel Grade

This indicates the strength with which the bonding material holds the abrasive grains in the grinding wheel. Grade determines the degree of hardness or softness of a grinding wheel. The term "grade" as applied to a grinding wheel refers to the tenacity or hardness with which the bond holds the cutting points or abrasive grains in place. The grade shall be indicated in all bonds and processes by a letter of the English alphabet. A denoting the softest and the letter Z denoting the hardest grade. The selection of a grinding wheel depends upon the nature of work, its composition, size and hardness.

A= very soft grinding wheel
Z = very hard grinding wheel
The following classification is employed for grade:
A—E: Very soft,
G—K: Soft,
L—O: Medium,
P—S: Hard,
T—Z: Very hard.

3. Grain spacing

Spacing or structure, from 1 (densest) to 17 (least dense). Density is the ratio of bond and abrasive to air space. A less-dense wheel will cut freely, and has a large effect on surface finish. It is also able to take a deeper or wider cut with less coolant, as the chip clearance on the wheel is greater.

4. Wheel Bonds

A bond is an adhesive material used to *held abrasive particles together*; relatively stable that constitute a grinding wheel. Bonding materials are used to *hold the abrasive particles in place*.
The following notations are followed:
V—Vitrified,
B—Resinoid,
BF—Resinoid reinforced
R—Rubber,

RF—Rubber reinforced
E—Shellac,
S—Silicate,
Mg—Magnesia

Type of Bond

Vitrified Bond:
This bond consists of mixture of clay and water. Clay and abrasives are thoroughly mixed with water to make a uniform mixture. The mixture is molded to shape of a grinding wheel and dried up to take it out from mold.
This wheel possess a good strength and porosity to allow high stock removal with coal cutting. Disadvantage of this type of wheel are, it is Sensitive for heat, water, oil and acids. Their impact and bending strengths are also low. This bond is denoted by symbol 'V' in specification.
Silicate Bond
Silicate bonds are made by mixing abrasive particles with silicate and soda or water glass. It is molded to required shape, allowed to dry up and then taken out of mold. The raw molded wheel is baked in a furnace at more than 200^{O}C for several days. These wheel exhibits water proofing properly so these can be used with coolant. These wheels are denoted by 'S' in specification.
Shellac Bond
These are prepared by mixing abrasive with shellac than molded by rolling and pressing and then by heating up to 150^{O}C for several hours. This bond exhibit greater elasticity than other bonds with appreciable strength. Grinding wheels having shellac bond are recommended for cool cutting on hardened steel and thin sections, finishing of chilled iron, cast iron, steel rolls, hardened steel cams and aluminium pistons. This bond is denoted by 'E' in specifications.

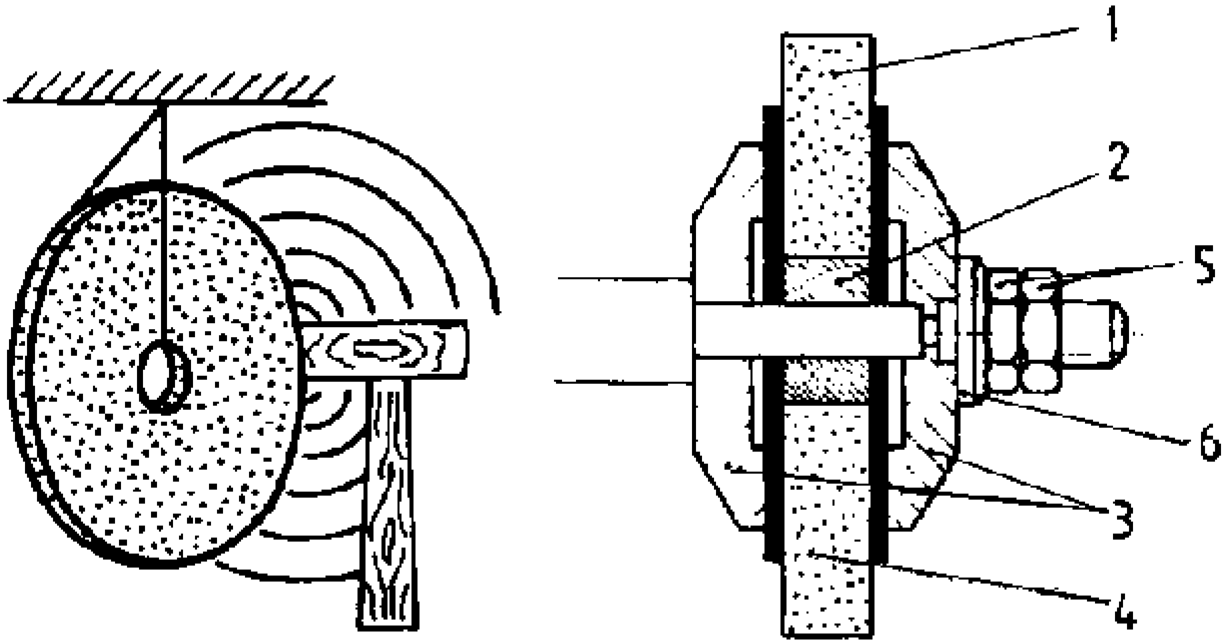
Resinoid Bond
These bonds are prepared by mixing abrasives with synthetic resins like Bakelite and redmanol and other compounds. Mixture is molded to required shape and baked up to 200^{O}C to give a perfect grinding wheel. These wheels have good grinding capacity at higher speed. These are used for precision grinding of cams, rolls and other objects where high precision of surface and dimension influence the performance of operation. A resinoid bond is denoted by the letter 'B'.
Rubber Bond
Rubber bonded wheels are made by mixing abrasives with pure rubber and Sulphur. After that the mixture is rolled into sheet and wheels are prepared by punching using die and punch. The wheels are vulcanized by heating then in furnace for short time. Rubber bonded wheels are more resilient and have larger abrasive density. These are used for precision grinding and good surface finish. Rubber bond is also preferred for making thin wheels with good strength and toughness. The associated disadvantage with rubber bond is, these are lesser heat resistant. A rubber wheel bonded wheel is denoted by the letter 'R'.
Oxychloride Bond

These bonds are processed by mixing abrasives with oxides and chlorides of magnesium. The mixture is molded and baked in a furnace to give shape of a grinding wheel. These grinding wheels are used for disc grinding operations. An oxychloride bonded wheel is specified the letter 'O'.

- **Content/Topic 2 Mounting Procedure**

Proper steps in mounting a grinding wheel are as follows:

1. Handle and store grinding wheels in a careful manner.
2. Select the proper grinding wheel and machine for the job.
3. Lock out and tag all machines before working on them.
4. Visually inspect all grinding wheels.



With mounting the grinding wheel, observe the following order:

a) Sound out the grinding wheel if it has a ceramic bond (clear, slowly dying away sound - faultless wheel)
b) If the bore hole is too big, put a lead bushing (2) into the wheel (1);
c) Clamp the wheel (1) between two flanges of the same size (3);
d) Put soft, elastic washers of rubber or cardboard (4) between the wheel and the flanges;
e) Fasten the wheel by a bolt washer (6) and a lock nut (5) on the shaft.

Pay attention that the right end of the shaft has a right-hand thread, the left end of the shaft a left-hand thread. Then. The spark killer has to be adjusted so that the maximum distance between the spark killer and the grinding wheel is approximately 5 mm. The grinding support must not be more than 1 - 2 mm away from the grinding wheel, because otherwise there is the risk of thin tools being drawn in.

Since the size of the grinding wheel is reduced by abrasion during the grinding process, the distances must be permanently put right.

Dressing diamonds are applied with the help of dressing devices, if very great demands are made on the grinding wheel as to the precision of dimensions and form as well as surface quality.

Precautions to be taken before mounting a grinding wheel:

In the interest of satisfactory operation and safety, it is important that grinding wheels are mounted correctly on the machine and before mounting they should be examined for any defects.

1. The wheel should be first examined for any flaw or crack which, under stresses set up due to high speed of rotation, might lead to fracture of the wheel, thus causing serious accident.

For testing this, the wheel is supported with the fingers in the bore and struck lightly with a piece of wood. If any crack is present, it can be judged by the sound produced. The sound of vitrified and silicate wheels gives a clear, bell like ring when struck.

2. Wheel Balance:

Out-of balance and out-of-round wheels result in vibrations and poor surface finish, faster wheel breakdown and sometimes even cause injury to the operator. For this the wheel is mounted at the centre of a perfectly straight and round spindle, the assembly is then rested on level knife-edge ways.

The test should be carried out after turning up the wheel face and mounting it on its spindle. If there is any unbalance, wheel will come to rest with its heavy side underneath. Error is rectified by cutting some of the lead from heavy side of bush.

Other way is to adjust the position of the slotted weights provided in the rim of the flange. These adjustable segments can be fixed round a circle at any position by tightening the screws. Best results are achieved by dynamically balancing the wheel.

3. The sides of the wheel and the flanges which clamp the wheel should be flat and bear evenly all the around.

4. The lead bushing should be an easy fit and no force be used.

5. The back, fixed flange should be keyed, shrunk or otherwise fixed to the spindle in order to transmit the power from the spindle to the wheel.

6. Both flanges must be relieved so that they only bear on the wheel at their rim. On no account must one of them or both should touch the sides or the wheel anywhere else. Blotting paper or rubber washer should be used between the flanges and the wheel.

7. Both flanges should be of the same size, the diameter being preferably equal to one-half the diameter of the grinding wheel. If they are not equal in diameter, then bending stresses will be induced.

8. The nut should be tightened only just enough to hold the wheel. The undue tightness is unnecessary and not desirable.

9. When wheel is mounted for the first time it should be made to run idle for some time.

10. Safety guard should always be used, so that in case of accident operator is not injured.

11. The cut type wheel is usually inclined by a little amount so that arc of contact is decreased and also the lay is unidirectional and does not cross each other. Thus when two surface rub, jamming effect is also not observed.

12. The wheel speed chosen should be proper.

13. If possible, some proper lubricant should be used in grinding operation and while grinding cast iron job, dust collector should also be operated.

LO 4.2 Grind of cutting tool

- **Content/Topic 1 Cutting Tool Angles**

Cutting tool geometry concerns with basic tool angles i.e angles ground on tool to make it efficient in cutting. A single point cutting tool as shown in figure has only one cutting edge.
The following are the angle obtain on single point cutting tool

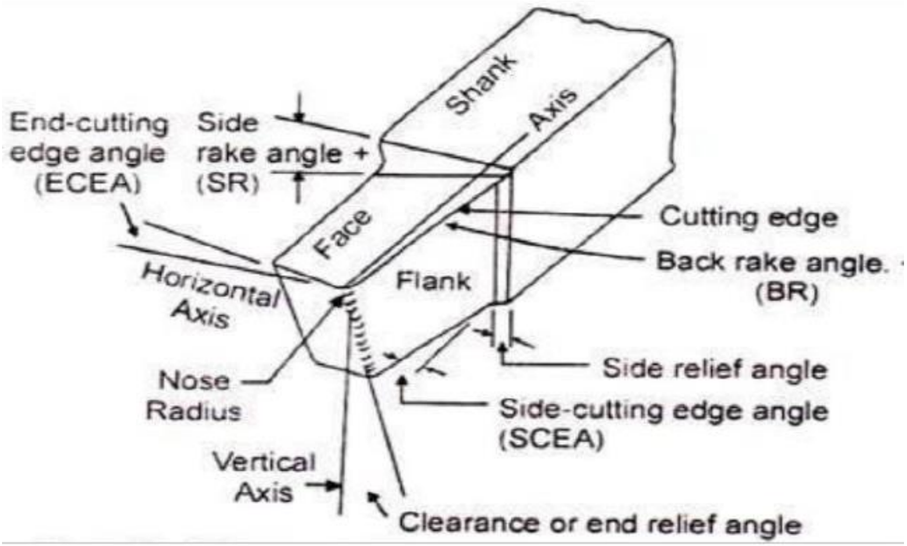
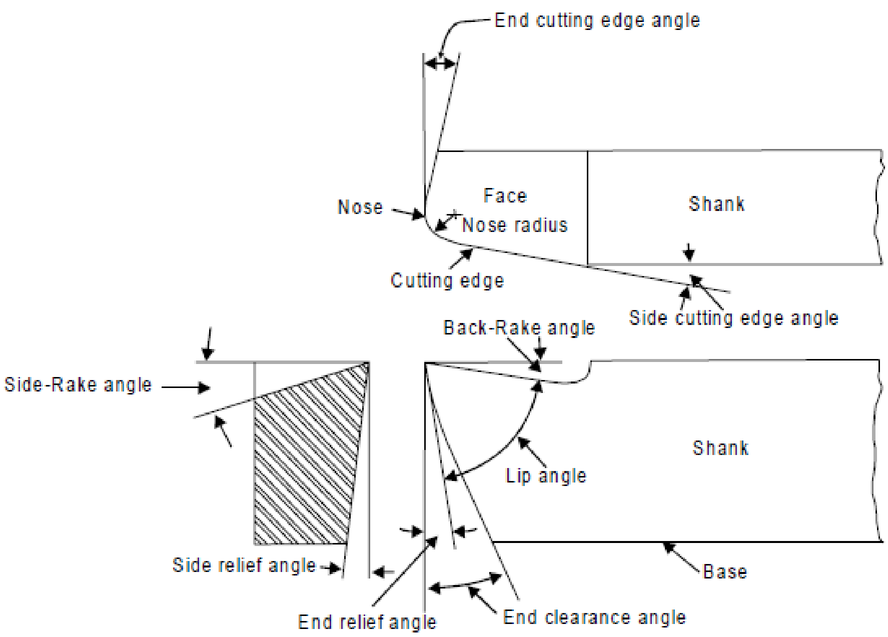


Figure 31: Cutting Tool Angles



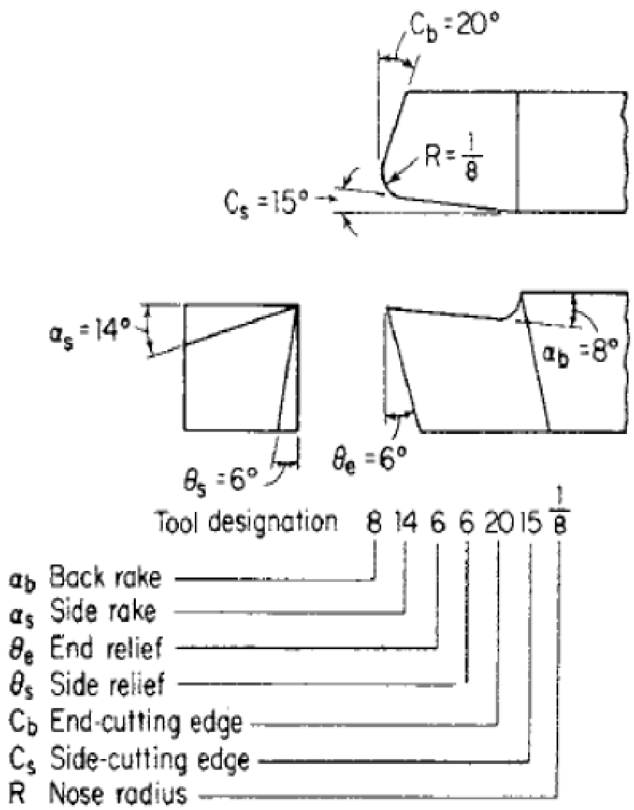


Figure 32: Cutting tool Angles

Rake Angle (α):

(a) Back rake angle.

(b) Side rake angle.

Material	***Rake angle***	***Machinability***
Grey cast iron	0°-10°	Brittle
Brass	0°-6°	Brittle
Tool steel	8°-12°	Fairly ductile
Mild steel	15°-20°	Ductile
Copper	35°-40°	Very ductile
Aluminium	35°-40°	Very ductile
Perspex	40°-50°	Extremely ductile

Clearance or Relief Angle (γ):

The purpose of a clearance angle is to reduce the energy required to shear the metal, by removal or reduction of friction arising from the rubbing action between the tool and the work.

(a) End clearance relief angle.

(b) Side clearance relief angle.

Cutting Edge Angle:

(a) End cutting edge angle.

(b) Side cutting edge angle.

(i) Back Rake Angle:

It is the angle between the face of the tool and plane parallel to its base. It is also known as front rake angle or top rake angle.

Functions of Back Rake Angle:

(a) It helps to control the chip flow in a convenient direction.

(b) It reduces the cutting force required to shear the metal and consequently helps to reduces power requirements and increase tool life.

(ii) Side Rake Angle:

It is the angle between the face of the tool and the shank of the tool.

Functions of Side Rake angle:

(a) It performs similar functions as performed by back rake angle.

(b) Side rake angle along with back rake angle controls the chip flow direction.

(iii) End Clearance (Relief) Angle:

It is the angle between the front surface of the tool and a line normal to the base of the tool. It is also known as front clearance angle.

Functions of End Clearance (relief) Angle:

(a) It allows the tool to cut freely without rubbing against the work surface.

(b) This angle varies from 0° to 15°, and usually 8°.

(c) Excessive relief angle reduces strength of the tool.

(iv) Side Clearance (Relief) Angle:

It is the angle between the side surface of the tool and a line normal to the base of the tool.

Functions of Side Clearance (relief) Angle:

i. It avoids the rubbing of flank against the work piece when the tool is fed longitudinally.

ii. This angle is 6° to 10° for steel, 8° for aluminum.

iii. It maintains that no part of the tool besides the actual cutting edge can touch the work.

(v) End Cutting Edge Angle:

It is the angle between the end cutting edge of the tool and a line perpendicular to its shank.

Functions of End Cutting Edge Angle:

i. It avoids rubbing between the edge of the tool and workspace.

ii. It influences the direction of chip flow.

(vi) Nose Radius:

Nose radius is one which connects the side and end cutting edge.

Functions of Nose Radius:

i. A sharp point at the end of tool is undesirable, because it is highly stressed, short lived and leaves groove in the path of cut.

ii. Therefore Nose Radius is favorable for long tool life and good surface quality.

vii. Larger nose radius means larger area of contact between tool and work piece. Resulting more frictional heat is generated. Also, cutting force increases due to which the work part may start vibrating and chattering, if work part holding is not very tight.

Tool Signature:

Tool signature is the specification or nomenclature of the tool which provides information regarding various tool angles and nose radius.

It includes seven parameters in specified order as given below:

(i) Back rake angle.

(ii) Side rake angle.

(iii) End relief (clearance) angle.

(iv) Side relief angle,

(v) End cutting edge angle.

(vi) Side cutting edge angle.

(vii) Nose radius.

- **Content/Topic 2: use of Wheel Dresser**

Grinding dressers are used to return a wheel to its original round shape (to true it up), to expose fresh grains for renewed cutting action (including cleaning away clogged areas), or to make a different profile (cross-sectional shape) on the wheel's edge.

The purpose of dressing is to restore the correct cutting action of the wheel. Dressing removes the clogs on the surface of the wheel and the blunt grains of the abrasive, exposing the new sharp abrasive grains of the wheel which can be cut and brought to shape efficiently.

Truing Of Grinding Wheel

Truing refers to the shaping of the wheel to make it run concentric with the axis. When a new grinding wheel is mounted, it must be trued before use. The cutting surface of a new wheel may run out slightly due to the clearance between the bore and the machine spindle. Grinding wheels which are in use also can run out of true due to uneven loading while grinding.

Dressing and truing are done at the same time. Same tool is used for both dressing and Truing.

GRINDING WHEEL DRESSER

1. **Star Wheel Dressers**

The wheel dresser used for off-hand grinders are Star Wheel Dresser (Huntington type Wheel dresser) and Diamond dresser.

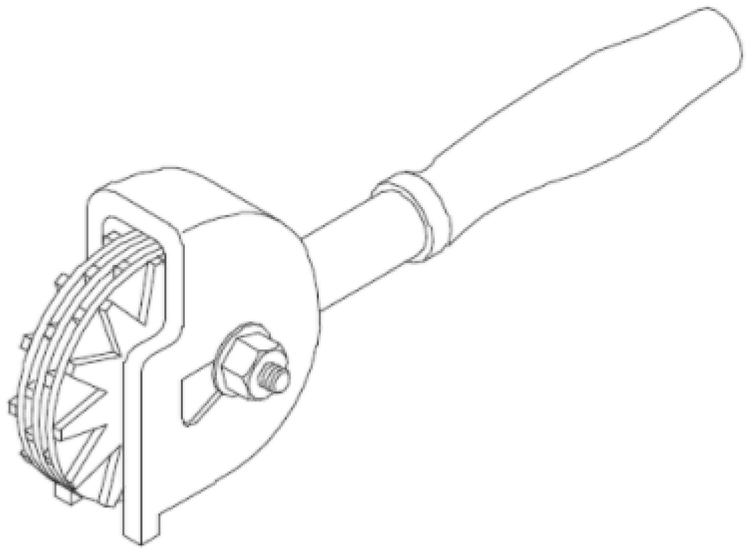
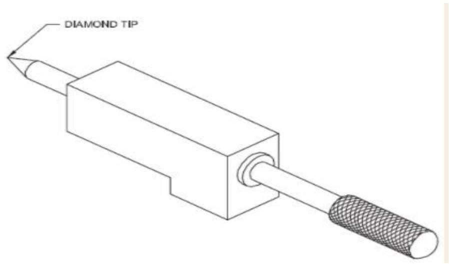


Figure 33: Star Wheel Dresser

The star dresser consists of a number of hardened star- shaped wheels mounted on a spindle at one end and a handle ate the other end. While dressing, the star wheel is pressed against the face of the revolving grinding wheel. The star wheel revolves and digs into the surface of the grinding wheel. This releases the wheel loading and dull grains, exposing sharp new abrasive grains.

Star wheels are useful for pedestal grinders in which a precision finish is not expected. Star wheel dressers should be used only on wheels which are large enough to take the load.

2. **Diamond dresser**



LO 4.3 Use coolant during sharpening

- **Content/Topic 1: Types of coolants**

  - **Water soluble oils**

Coolants are water soluble fluids designed to provide cooling and lubrication during metalworking operations. The use of coolant extends cutting tool life, improves part finish and tolerance, and improves productivity. Ashburn's APEX line of coolants utilizes the latest technologies to develop leading-edge products.

These oils are neat in so much as they are not mixed with water for the cutting operation.

They are usually a blend of a number of different types of mineral oil, together with additives for extreme-pressure applications. Neat cutting oils are used where severe cutting conditions exist, usually when slow speeds and feeds are used or with extremely tough and difficult-to-machine steels. These conditions require lubrication beyond that which can be achieved with soluble oils.
In some cases soluble oil cannot be used, due to the risk of water mixing with the hydraulic fluid or the lubricating oil of the machine. A neat oil compatible with those of the machine hydraulic or lubricating system can be used without risk of contamination.
Neat cutting oils do not have good cooling properties and it is therefore more difficult to maintain good dimensional accuracy. They are also responsible for dirty and hazardous work areas by seeping from the machine and dripping from workpieces and absorbing dust and grit from the atmosphere.
Low-viscosity or thin oils tend to smoke or fume during the cutting operation, and under some conditions are a fire risk.
The main advantages of neat cutting oils are their excellent lubricating property and good rust control. Some types do, however, stain non-ferrous metals.

Water is the cheapest cooling medium, but it is unsuitable by itself, mainly because it rusts ferrous metals. In soluble oils, or more correctly emulsifiable oils, the excellent cooling property of water is combined with the lubricating and protective qualities of mineral oil. Oil is, of course, not soluble in water, but with the aid of an agent known as an emulsifier it can be broken down and dispersed as fine particles throughout the water to form an emulsion.
Other ingredients are mixed with the oil to give better protection against corrosion, resistance to foaming and attack by bacteria, and prevention of skin irritations. Under severe cutting conditions where cutting forces are high, extreme-pressure (EP) additives are incorporated which do not break down under these extreme conditions but prevent the chip welding to the tool face.
Emulsions must be correctly mixed, otherwise the result is a slimy mess. Having selected the correct ratio of oil to water, the required volume of water is measured into a clean tank or bucket and the appropriate measured volume of soluble oil is added gradually at the same time as the water is slowly agitated. This will result in a stable oil/water emulsion ready for immediate use.
At dilutions between 1 in 20 and 1 in 25 (i.e. 1 part oil in 20 parts water) the emulsion is milky white and is used as a general-purpose cutting fluid for capstan and centre lathes, drilling, milling and sawing.
At dilutions from 1 in 60 to 1 in 80 the emulsion has a translucent appearance, rather than an opaque milky look, and is used for grinding operations.
For severe cutting operations, such as gear cutting or broaching and machining tough steels, fluids with EP additives are used at dilutions from 1 in 5 to 1 in 15.
As can readily be seen from the above, when the main requirement is direct cooling, as in the case of grinding, the dilution is greater, i.e. 1 in 80. When lubrication is the main requirement, as with gear cutting, the dilution is less, i.e. 1 in 5.
The advantages of soluble oils over neat cutting oils are their greater cooling capacity, lower cost, reduced smoke and elimination of fire hazard. Disadvantages of soluble oils compared with neat cutting oils are their poorer rust control and that the emulsion can separate, be affected by bacteria and become rancid.

- **Synthetic fluids**

Sometimes called chemical solutions, these fluids contain no oil but are a mixture of chemicals dissolved in water to give lubricating and anti-corrosion properties. They form a clear transparent solution with water, and are sometimes artificially colored.
They are very useful in grinding operations, where, being non-oily, they minimise clogging of the grinding wheel and are used at dilutions up to 1 in 80. As they are transparent, the operator can see the work, which is also important during grinding operations.
They are easily mixed with water and do not smoke during cutting. No slippery film is left on the work, machine or floor. They give excellent rust control and do not go rancid.
At dilutions of between 1 in 20 and 1 in 30 they can be used for general machining.

- **Petroleum-based oils:**

Petroleum-based oil describes a broad range of natural hydrocarbon-based substances and refined petroleum products, each having a different chemical composition. As a result, each type of crude oil and refined product has distinct physical properties. These properties effect the way oil spreads and breaks down, the hazard it may pose to marine and human life, and the likelihood that it will pose a threat to natural and man-made resources.

The rate at which an oil spill spreads will determine its effect on the environment. Most oils tend to spread horizontally into a smooth and slippery surface, called a *slick*, on top of the water. Factors which affect the ability of an oil spill to spread include:

- **Surface tension** - the measure of attraction between the surface molecules of a liquid. The higher the oil's surface tension, the more likely a spill will remain in place. If the surface tension of the oil is low, the oil will spread even without help from wind and water currents. Because increased temperatures can reduce a liquid's surface tension, oil is more likely to spread in warmer waters than in very cold waters.
- **Specific gravity** - the density of a substance compared to the density of water. Since most oils are lighter than water, they lie flat on top of it. However, the specific gravity of an oil spill can increase if the lighter substances within the oil evaporate.

Viscosity - the measure of a liquid's resistance to flow. The higher the viscosity of the oil, the greater the tendency for it to stay in one place.

CUTTING FLUIDS

Cutting is accompanied with two major effects, these are friction and heat. Considering the tool life and quantity of finish, it is necessary to apply a cutting fluid to the operation of cutting, where primary function includes:
a) To carry away heat and
b) Provide lubrication where the chip bears at the tool face
Secondary functions performed by cutting fluids are
c) To flush away swart and keep the cutting zone clear and
d) To protect the newly machined surface from rusting.

In any particular operation the choice as to whether heat removal or lubrication is the more important function and the dependent determination as to the most suitable fluid is often a problem of some complexity, but there are certain fairly well-defined principles for guidance.
In addition to its property of cooling and lubrication, it is desirable for cutting fluids to possess the following properties:
a) Stability under heat or prolonged exposure. (Heat or exposure may cause some oils to decompose or oxidize with the liberation of fatty acids which may cause ill effects to work and to machine tools. Other oils may tend to become gummy and when in this condition will obstruct the feed pipes of a cooling system.
b) When applied to the heated cutting point, the oil should not fume or smoke unduly.
c) The cutting fluid should not contaminate the lubricating oil employed elsewhere on the machine.
d) At no stage in its condition should the fluid be injurious to the skin of operator or open wounds. (For this reason, an antiseptic is often added)
Before any fluid is considered for a particular use, the following should be taken into account. Whether
a) To cool
b) To cool and lubricate
c) To lubricate mainly, or
d) To minimize adhesion between chip and tool.
In any operation the heat generated is imparted to the chip, the tool and the work piece in various proportions according to the class of operation.

Functions or Uses of Coolants or Cutting Fluids

The important functions of cutting fluids are given as under.

i. Cutting fluid washes away the chips and hence keeps the cutting region free.
ii. It helps in keeping freshly machined surface bright by giving a protective coating against atmospheric, oxygen and thus protects the finished surface from corrosion.
iii. It decreases wear and tear of cutting tool and hence increases tool life.
iv. It improves machinability and reduce power requirements
v. It prevents expansion of work pieces.
vi. It cools the tool and work piece and remove the generated heat from the cutting zone.
vii. It decreases adhesion between chip and tool; provide lower friction and wear, and a smaller built-up edge.

In general, the use of cutting fluids can result in

- ✓ less wear on cutting tools,
- ✓ the use of higher cutting speeds and feeds,
- ✓ improved surface finish,
- ✓ reduced power consumption,
- ✓ Improved control of dimensional accuracy.

The ideal cutting fluid, in achieving the above, should

- ✓ not corrode the work or machine,
- ✓ have a low evaporation rate,
- ✓ be stable and not foam of fume,
- ✓ Not injure or irritate the operator.

Learning unit 5: Set the machine and mount the workpiece

LO 5.1 set the lathe machine

- **Content/Topic 1 Metal Cutting Parameter Settings**

For any machining or metal cutting operation, three relative motions between the workpiece and cutting tool are indispensably necessary for gradual removal of material from the workpiece. In fact, the simultaneous action of all three relative motions causes advancement of cutting tool towards work material along the intended path generating a finished surface with intended shape, size and tolerance. These three relative motions are called Cutting Parameters.
There process parameters in machining are all those parameters that are inherent to any machining operation and should have a suitable finite value to smooth and efficient removal of materials. Such parameters directly affect machining performance. In machining, three process parameters are:

- **Cutting speed or cutting velocity**
- **Feed rate**
- **Depth of cut**

Speed, Feed, and Depth of Cut

1. Cutting speed is defined as the speed (usually in feet per minute) of a tool when it is cutting the work.
2. Feed rate is defined as tool's distance travelled during one spindle revolution.
3. Feed rate and cutting speed determine the rate of material removal, power requirements, and surface finish.
4. Feed rate and cutting speed are mostly determined by the material that's being cut. In addition, the deepness of the cut, size and condition of the lathe, and rigidity of the lathe should still be considered.
5. As the softness of the material decreases, the cutting speed increases. Additionally, as the cutting tool material becomes stronger, the cutting speed increases.

a) Cutting speed

A lathe work cutting speed may be defined as the rate at which a point on the work circumference travels past the cutting tool. Cutting speed is always expressed in meters per minute (m/min) or in feet per minute (ft/min.) industry demands that machining operations be performed as quickly as possible; therefore current cutting speeds must be used for the type of material being cut. If a cutting speed is too high, the cutting tool edge breaks down rapidly, resulting in time lost recondition the tool. With too slow a cutting speed, time will be lost for the machining operation, resulting in low production rates. Based on research and testing by steel and cutting tool manufacturers, see lathe cutting speed table below. The cutting speeds for high speed steel listed below are recommended for efficient metal removal rates. These speeds may be varied slightly to shift factors such as the condition of the machine, the type of work material and sand or hard spots in the metal.

The cutting speed is the distance travelled by a point on the outer surface of the work in one minute. It is expressed in meters per minute.

Why is proper Cutting Speed important?

When set too high the tool breaks down quickly, time is lost replacing or reconditioning the tool. Too low of a CS results in low production.

Cutting speed = $\frac{\pi D n}{1000}\ m/min$

Where d: is the diameter of the work in mm

N: is the rpm (revolution per minute) of the work

The rotation speed in turning is related to the desired cutting speed at the surface of cylindrical workpiece by the equation:

$$N=\frac{v}{\pi d o}$$

Where N= rotational speed rev/min

V: cutting speed m/min (ft/min)

D_0= original diameter of the part m (ft)

b) Setting speeds on a lathe:

The lathes are designed to operate at various spindle speeds for machining of different materials. There speeds are measured in RPM (revolutions per minute) and are changed by the cone pulleys or gear levels. One a belt-driven lathe, various speeds are obtained by changing the flat belt and the back gear drive. One the geared-head lathe speeds are changed by moving the speed levers into proper positions according to the RPM chart fastened to the lathe machine (mostly on headstock). While shifting the lever positions, place one hand on the faceplate or chuck, and form the face plate slowly by hand. This will enable the levers for engage the gear teeth without clashing. Never change speeds when the lathe is running on lathers equipped with variable speed drivers, the speed is changed by turning a dial of handle while he machine is running.

c) Depth of cut setting

The tertiary cutting motion that provides necessary depth within work material that is intended to remove by machining. It is given in the third perpendicular direction and the simultaneous action of three cutting parameters results in removal of excess material from workpiece.

The depth of cut is the perpendicular distance measured from the machined surface to the uncut surface of the workpiece. It is expressed in millimeters.

In a lathe, the depth of cut is expressed as follows:

$$D_f = D_0 - 2d$$

The turning operation reduces the diameter of the work from its original diameter $\mathbf{D_o}$ to the final diameter $\mathbf{D_f}$ as determined by the depth of cut **d.**

To Set an Accurate Depth of Cut

Procedure:

1. Set the compound rest at 30 degrees.
2. Attach a roughing or finishing tool. Use a right-handed turning tool if feeding the saddle in the direction of the headstock.
3. Move the tool post to the left hand side of the compound rest and set the tool bit to right height center.
4. Set the lathe to the correct speed and feed for the diameter and type of material being cut.
5. Start the lathe and take a light cut about 0.127 mm and 6.35 mm long at the right hand end of the workpiece.
6. Stop the lathe, but do not move the crossfeed screw handle.
7. Move the cutting tool to the end of the workpiece (to the right side) by turning the carriage hand wheel.
8. Measure the work and calculate the amount of material to be removed.
9. Turn the graduated collar half the amount of material to be removed. For example, if .060 inch to be removed, the graduated collar should be turned in .030 inch, since the cut is taken off the circumference of the workpiece.
10. **Remember**, for each thousandth depth of cut, the diameter of the stock is reduced by two thousandths.

d) Feed rate setting

The feed of on lathe, or the distance the carriage will travel in on revolution of the spindle, depends on the speed of the feed rod or lead screw. This is controlled by the change gears in the quick-change gearbox. This quick change gearbox obtains its drive from the head stock spindle through the end gear train. A feeds and thread chart mounted on the front of the quick-change gearbox indicates the various feeds and metric pitches or thread per inch which may be obtained by setting levers to the **positions indicated.**

Feed rate

The auxiliary cutting motion is provided by the feed rate or feed velocity. Usually the direction of feed velocity is perpendicular to that of the cutting velocity; however, not necessary. The primary objective of feed velocity is to advance the cutter with respect to the workpiece to remove material from a wider surface. Basically it helps in covering the entire surface of the workpiece by moving either cutting tool or workpiece. Feed rate can be imparted either on the cutter or on the workpiece.

Feed

The feed of a cutting tool in a lathe work is the distance the tool advances for each revolution of the work. Feed is expressed in millimeters per revolution.

The feed in turning is generally expressed in mm/rev. this feed can be converted to a linear travel rate in mm/min by the formula

$$\boxed{F_r = Nf}$$

Where F_r: feed rate mm/min
F: feed mm/rev

Further aspects in connection with the selection of the feed are the surface quality and the material of the workpiece. What diameter is chosen for the calculation of the cutting speed with finishing?
For operating the regular engine lathe, the following rules have to be observed (sequence of operations):
- Switching the lathe on
- Approaching the tool carrier with the lathe tool towards the workpiece
- Entering the cut at the workpiece with the help of the hand feed
- Infeed by tool rest and surfacing of the workpiece
- Setting of the dog, length adjustment by log measure
- Beginning the cut at the area of the cylindrical surface of the workpiece by hand feed
- Putting the scale of the cross slide on 0 and carry out the required feed operation for achieving the desired diameter (in the case of too much infeed, turn the crank back by one revolution in order to compensate backlash and start the feeding movement again).
- Starting the cut with 1-2 mm, then the tool carrier is returned
- Switching the machine off and dimensional inspection
- Switching the machine on - perhaps dimensional correction
- Switching on the automatic feed
- 1 - 2 mm before reaching the stop, switch the automatic feed off and continue by hand feed till the stop is reached.

e) Tool geometry Setting

• Move the toolpost to the left-hand side of the compound rest.
• Mount a toolholder in the toolpost so that the set screw in the toolholder is about 1 inch beyond the toolpost.
• Insert the proper cutting tool into the toolholder, having the tool extend .500 inch beyond the toolholder.
• Set the cutting tool point to center height. Check it with straight rule or tailstock.
• Tighten the toolpost securely to prevent it from moving during a cut

It is essential that all cutting tools used on a lathe be set on the centre of the workpiece.
A tool set too high reduces the clearance and will rub, while one set too low reduces the rake angle,Cutting tools can be set relative to a centre inserted in the tailstock and then be raised or lowered using suitable thicknesses of packing. A good stock of varying thickness of packing should be available which, when finished with, should always be returned for future use.
Effect of tool set above and below centre

Tool Signature:

Tool signature is the specification or nomenclature of the tool which provides information regarding various tool angles and nose radius.

It includes seven parameters in specified order as given below:

(i) Back rake angle.

(ii) Side rake angle.

(iii) End relief (clearance) angle.

(iv) Side relief angle,

(v) End cutting edge angle.

(vi) Side cutting edge angle.

(vii) Nose radius.

For example:

If the tool signature is 12, 15, 7, 6, 10, 15, 0.8

Means,

Back rake angle (degree): 12

Side rake angle: 15

End relief angle: 07

Side relief angle: 06

End cutting edge angle: 10

Side cutting edge angle: 15 and (i) Nose radius (mm): 0.8

f) Tail stock set over setting

Taper Turning can be done in Lathe by tailstock setover method, in which the tailstock is moved from its middle position to one side of the bed, making the work-piece tilted wrt the lathe axis and feed. Thus, when the tool moves, it cut the workpiece at an angle to its axis, creating a taper. The tail stock set over method of taper turning is preferred for Long slender tapers

One way to turn slow tapers, between centres, is by offsetting the tailstock. To overcome this I made this tailstock offset device. This just clamps to the tailstock barrel and any offset, up to +/- 15 mm, can be set using the adjuster knob. This photo shows the front of the unit.

Tail stock set over method of taper turning is preferred for Long slender tapers

A surface may be turned in a lathe if the tool point is not fed parallel but at, a certain angle.

Taper Turning by Off Setting the Tailstock;

Taper can be machined on a job that can be turned between centres by setting over the tailstock. The method of setting over the tailstock. In this method the axis of the job rotates with an angle to machine bed axis and the tool moves parallel to the machine bed. Under this method the tailstock is off set on the basis the value of, which is in mm or inches instead of degrees. If the dead centre is set over in the opposite direction it will turn a taper its larger diameter on the side of the tailstock.

EXERCISES

1. Determine the cutting speed in machining a workpiece of 200 mm diameter rotating at a speed of 100 rpm. Also calculate machining time if workpiece length is 0.5 m and feed is 0.45 mm/rev.

Solution:

Given: diameter of the job: D= 200mm , speed N= 100rpm, feed (f)= 0.45m/min

Length of the job (L)= 0.5m= 500mm

Cutting speed V= $s = \frac{n \times d \times \pi}{1000} = \frac{\pi \times 200 \times 100}{1000} = 62.83m/min$

Machining time Tm = $\frac{L}{fN} = \frac{500}{0.45 \times 100} = 11.11min$

Where Tm: time required for turning

L: length of the job

f: feed per revolution (mm/rev)

N: revolution of the job per minute

2. A workpiece of a diameter of d = 200 mm rotates along the lathe tool at n = 30 r.p.m. What is the peripheral speed v?

$$v = \frac{n \times d \times \pi}{1000} = \frac{30 \times 200 \times 3.14}{1000} = 18.84 \text{ m/min.}$$

3. A disk of 200 mm shall be rough-machined at v = 100 m/min. The rotational speed n is to be determined.

Given: d = 200 mm, v = 100 m/min

$$\text{Calculation: } n = \frac{1000 \times v}{d \times \pi} = \frac{1000 \times 100}{200 \times 3.14} = 159.24$$

L.O 5.2: Fix the cutting tool

- **Content/Topic 1: Differentiation of Tool Post Keys**

A chuck key or wrench is a tool that is made for the purpose of tightening or loosening the jaws of a chuck. A chuck is a type of clamp that is used to hold a cylinder object. On a lathe, it holds the rotating piece—whereas on a drill or mill, it holds the rotating tool.

Leaving a chuck key in the lathe can be extremely dangerous. If the machine is turned on while the key is still in it, you risk the potential of the key flying out and injuring someone. With a self-ejecting key or wrench, it releases itself from the chuck after each use. This prevents someone from inadvertently leaving the key in the chuck as the main motor is started.

- **Flexbar Self Ejecting Chuck Wrench** - These spring-loaded, self-ejecting chuck wrenches are designed for use with lathes and other machines equipped with manually adjusted chucks. They come in a variety of different sizes—and each wrench has a chamfered end for easy use.

- **Self Ejecting Chuck Key** - These drill press chuck keys are spring-loaded and self-eject so they are not inadvertently left in a machine's chuck. These keys help with preventing projectile injuries and come in a variety of different sizes. They are designed for use with drills and other machines equipped with manually tightened Jacobs style chucks.

While having the right chuck key can make all the difference for a machine operator, proper safety training is equally important in preventing lathe operation accidents. With the right training, operators will understand how to use a lathe machine with a self-ejecting chuck wrench—as well as the importance of proper use in order to prevent injury to themselves and others in the workplace.

Figure 34: Socket Tool Post Key

Figure 35: Tool Post chuck

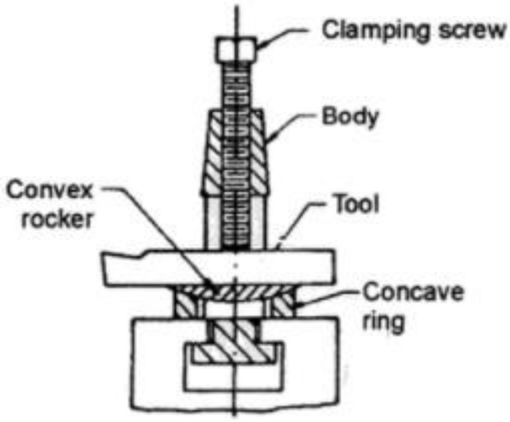
- **Content/Topic 2: Types of Tool Post**

Tool post is the device that is located on top of the compound slide. It is used to hold the tools rigidly. Tools are selected according to the type of operation and mounted on the tool post and adjusted to a convenient working position. There are different types of tool posts and they are:

I. Single screw tool post

Single screw toolpost consists of a round bar with a slotted hole in the center for fixing the tool by means of set screw. The toolpost with concave ring and convex rocker slides in a T-slot on the top of the compound rest.

Adjustment of tool height is made by tilting but this alters all the cutting angles of the tool.



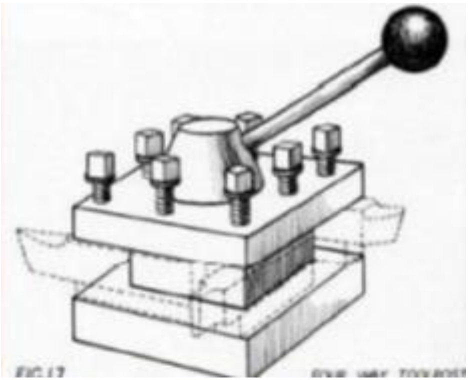
II. Four bolt tool post

In the four bolt tool post, the tool is held in position by two straps and four bolts. The adjustment for the tool height can be made by using parallel packing strips under the tools.

III. Four way tool post

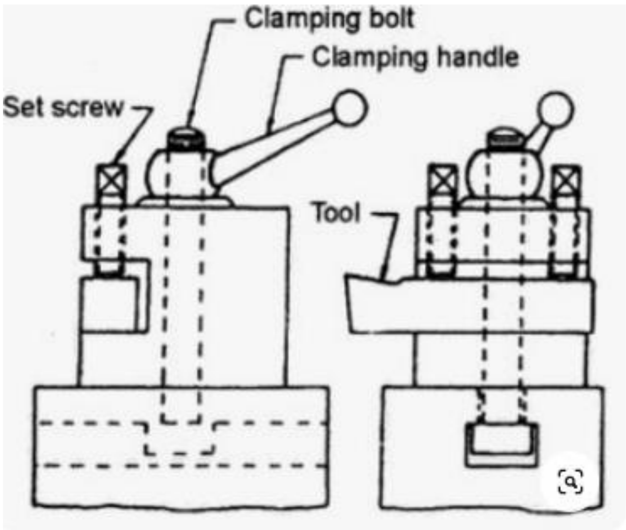
The height of the cutting point can be adjusted by using parallel packing strips. This arrangement ensures quick replacement of the tool. In four way tool post four sides are open to accommodate four tools at a time. The tools are fitted in proper sequence of operation and by indexing the tool post through 90^0 any one of the tools may be fed in to the work. This type is generally used in moderately heavy lathes and is suitable for repetition work.

Four tool post provides firm supports for both single or double tool set up. In this tool post, each tool is secured in the tool post by more than one bolt and so the rigidity is more.



IV. Open side tool post

In the open side tool post, the tool is held quite independent of the main fixing bolt and clamped in position by two set screws.



V. Quick change tool post

Quick-Change Lathe Tool Posts. Is a height-adjustment screw allows for quick and accurate adjustment of the tool height without the need for shimming.

- **Content/Topic 3: Tool positioning**

To reposition the cutting tool, move the cross slide and lathe saddle by hand. Power feeds are also available. Exact procedures are dependent on the machine. The compound provides a third axis of motion, and its angle can be altered to cut tapers at any angle.

1. Loosen the bolts that keep the compound attached to the saddle.
2. Swivel the compound to the correct angle, using the dial indicator located at the compound's base.
3. Tighten the bolts again.
4. The cutter can be hand fed along the chosen angle. The compound does not have a power feed.
5. If needed, use two hands for a smoother feed rate. This will make a fine finish.
6. Both the compound and cross slide have micrometer dials, but the saddle lacks one.
7. If more accuracy is needed when positioning the saddle, use a dial indicator that is attached to the saddle. Dial indicators press against stops.

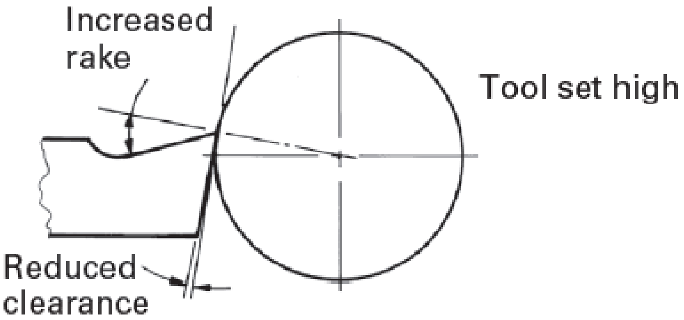


Figure 36:cutting tool setting high

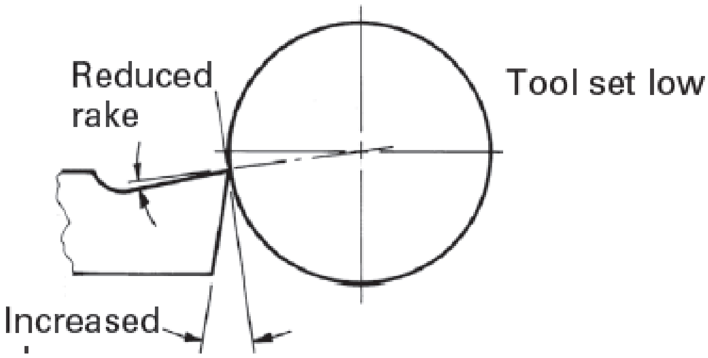


Figure 37: cutting tool set low

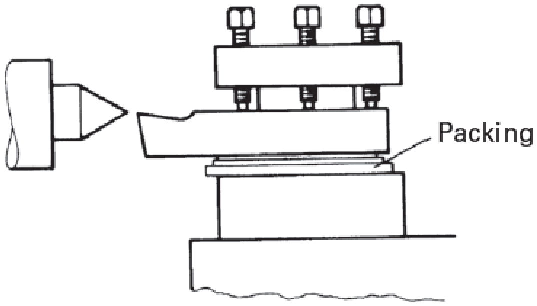


Figure 38: cutting tool setting on the center

Figure 39: Positionning Cutting Tool

L O 5.3: Fix the workpiece

- **Content/Topic 1: Methods of Mounting Workpiece**

a) To Mount Workpiece in chuck

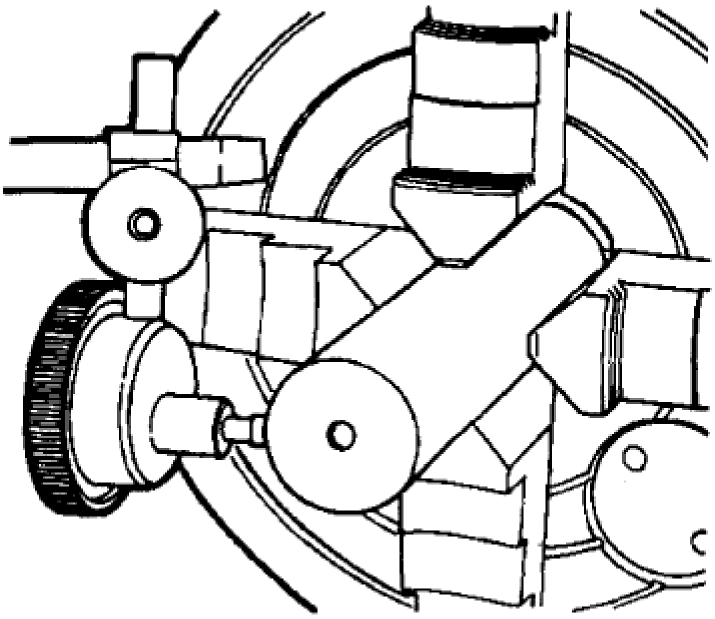
• Check that the line center is running true. If it is not running true, remove the center, clean all surfaces, and replace the center. Check again for trueness.
• Clean the lathe center points and the center holes in the workpiece.
• Adjust the tailstock spindle until it projects about 3 inch beyond tailstock.
• Loosen the tailstock clamp nut or lever.
• Place the end of the workpiece in the chuck and slide the tailstock up until it supports the other end of the workpiece.
• Tighten the tailstock clamp nut or level.

Installing a Cutting Tool

- Tool holders are used to hold lathe cutting tools.
- To install, clean the holder and tighten the bolts.
- The lathe's tool holder is attached to the tool post using a quick release lever.
- The tool post is attached to the machine with a T-bolt.

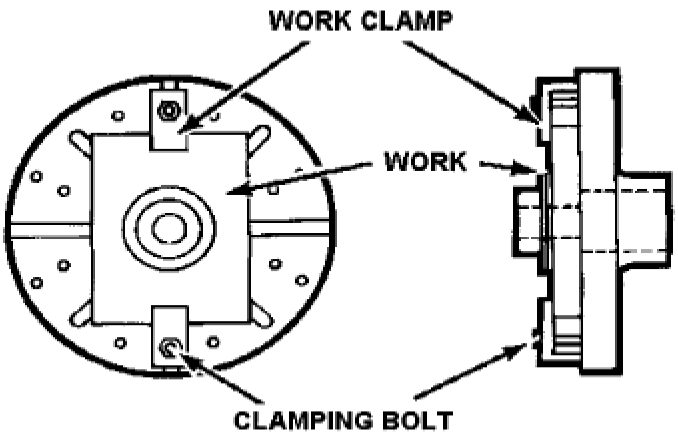
Work automatically centers itself in the universal (3 jaw) scroll chuck, drill chuck, collet chucks, and step chuck, but must be manually centered in the independent (4 jaw) chuck.
To center work in the independent chuck, line the four jaws up to the concentric rings on the face of the chuck, as close to the required diameter as possible.
Mount the workpiece and tighten the jaws loosely onto the workpiece. Spin the workpiece by hand and make approximate centering adjustments as needed, then firmly tighten the jaws.
For rough centering irregularly shaped work, first measure the outside diameter of the workpiece, then open the four jaws of the chuck until the workpiece slides in. Next tighten each opposing jaw a little at a time until the workpiece is held firmly, but not too tightly. Hold a piece of chalk near the workpiece and revolve the chuck slowly with your left hand.
Where the chalk touches is considered the high side.

Loosen the jaw opposite and tighten the jaw where the chalk marks are found. Repeat the process until the workpiece is satisfactorily aligned.



To center a workpiece having a smooth surface such as round stock, the best method is to use a dial test indicator.
Place the point of the indicator against the outside or inside diameter of the workpiece. Revolve the workpiece slowly by hand and notice any deviations on the dial. This method will indicate any inaccuracy of the centering in thousandths of an inch.
If an irregularly shaped workpiece is to be mounted in the independent chuck, then a straight, hardened steel bar can be used with a dial indicator to align the workpiece. Experienced machinists fabricate several sizes of hardened steel bars, ground with a 60° point, that can be mounted into the drill chuck of the tailstock spindle and guided into the center punched mark on the workpiece. A dial indicator can then be used to finish aligning the workpiece to within 0.001 inch. If a hardened steel bar is not readily available, a hardened center mounted in the tailstock spindle may be used to align the work while using a dial indicator on the chuck jaws. This method is one of several ways to align a workpiece in an independent chuck. Ingenuity and experience will increase the awareness of the machine operator to find the best method to set up the work for machining.

When removing chucks from the lathe, always use a wooden chuck block under the chuck to support the chuck on the lathe ways. Use care to avoid dropping the chuck on the ways, since this can greatly damage the lathe ways or crush the operator’s hands.



b) Mounting Work to Faceplates

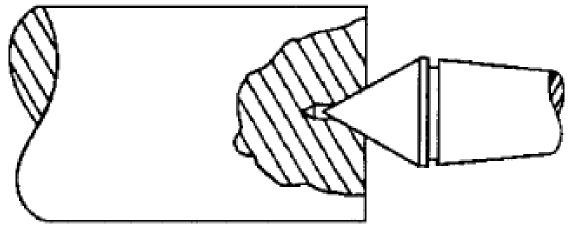
Mount faceplates in the same manner as chucks. Check the accuracy of the faceplate surface using a dial indicator, and true the-faceplate surface by taking a light cut if necessary. Do not use faceplates on different lathes, since this will cause excessive wear of the faceplate due to repeated truing cuts having to be taken. Mount the workpiece using T-bolts and clamps of the correct sizes (Fig: above). Ensure all surfaces are wiped clean of burrs, chips, and dirt. When a heavy piece of work is mounted off center, such as when using an angle plate, use a counterweight to offset the throw of the work and to minimize vibration and chatter. Use paper or brass shims between the work and the faceplate to protect the delicate surface of the faceplate. After mounting the work to an approximate center location, use a dial indicator to finish accurate alignment.

c) Work mounting between Jigs and fixture mounting

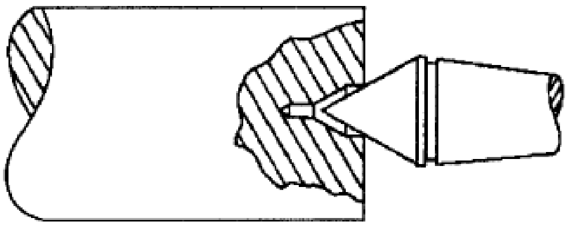
Jig is primarily used to guide the movement of cutter repeatedly at predefined locations on the work, and support and locate the part as well. Fixture is mainly used to secure, support and locate the workpiece and maintain predetermined orientation, not guide the cutter.
Jig is the device which guides the tool, while fixture is a device that securely holds the job in position during machining operations. The major difference between a jig and a fixture is that jigs guide the cutting tool to its precise position, as well as locating and supporting the work-piece during operations.
Location refers to the establishment of a desired relationship between the workpiece and the jigs or fixture correctness of location directly influences the accuracy of the finished product. The jigs and fixtures are desired so that all undesirable movements of the workpiece can be restricted.

d) Mounting Work between Centers

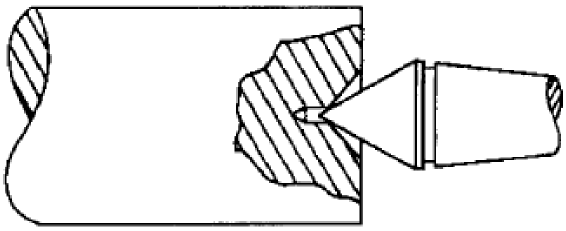
Before mounting a work- piece between centers, the workpiece ends must be center- drilled and countersunk. This can be done using a small twist drill followed by a 60° center countersink or, more commonly, using a countersink and drill (also commonly called a center drill). It is very important that the center holes are drilled and countersunk so that they will fit the lathe centers exactly. Incorrectly drilled holes will subject the lathe centers to unnecessary wear and the workpiece will not run true because of poor bearing surfaces. A correctly drilled and countersunk hole has a uniform 60° taper and has clearance at the bottom for the point of the lathe center. Fig below illustrates correctly and incorrectly drilled center holes.
The holes should have a polished appearance so as not to score the lathe centers. The actual drilling and countersinking of center holes can be done on a drilling machine or on the lathe itself. Before attempting to center drill using the lathe, the end of the workpiece must be machined flat to keep the center drill from running off center.



CORRECTLY DRILLED HOLE

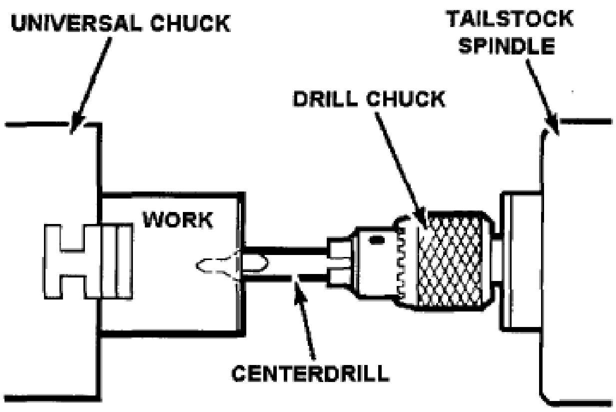


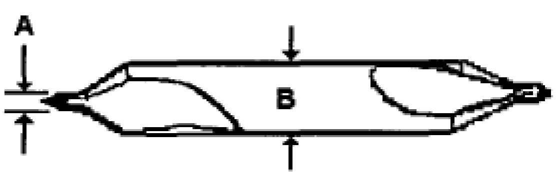
HOLE DRILLED TOO DEEP

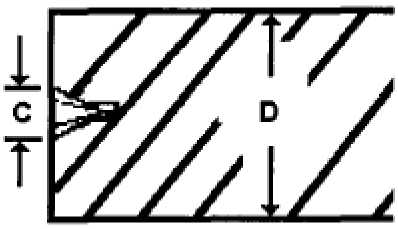


HOLE DRILLED TOO SHALLOW

Mount the work in a universal or independent chuck and mount the center drill in the lathe tailstock Refer to the section of this chapter on facing and drilling on the lathe, prior to doing this operation. Center drills come in various sizes for different diameters of work Calculate the correct speed and hand feed into the workpiece. Only drill into the workpiece about 2/3 of the body diameter.





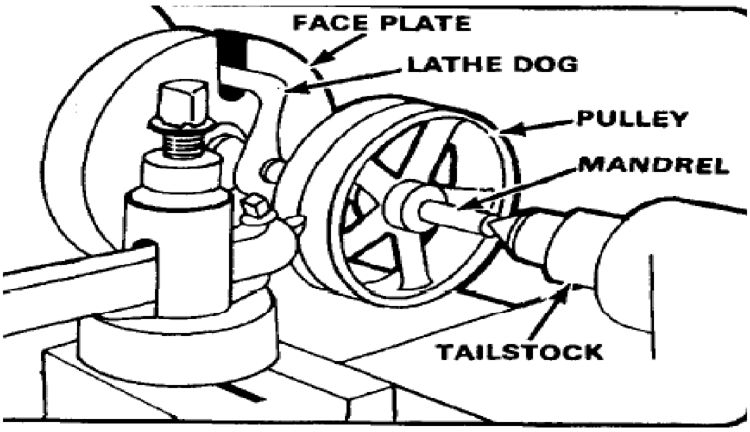


To mount work between centers, the operator must know how to insert and remove lathe centers. The quality of workmanship depends as much on the condition of the lathe centers as on the proper drilling of the center holes. Before mounting lathe centers in the headstock or tailstock,
Thoroughly clean the centers, the center sleeve, and the tapered sockets in the headstock and tailstock spindles. Any dirt or chips on the centers or in their sockets will prevent the centers from seating properly and will cause the centers to run out of true.

Install the lathe center in the tailstock spindle with a light twisting motion to ensure a clean fit. Install the center sleeve into the headstock spindle and install the lathe center into the center sleeve with a light twisting motion.
To remove the center from the headstock spindle, hold the pointed end with a cloth or rag in one hand and give the center a sharp tap with a rod or knockout bar inserted through the hollow headstock spindle.
To remove the center from the tailstock, turn the tailstock handwheel to draw the tailstock spindle into the tailstock. The center will contact the tailstock screw and will be bumped loose from its socket.

a) Mounting Work on Mandrels

To machine a workpiece of an odd shape, such as a wheel pulley, a tapered mandrel is used to hold and turn the work.
The mandrel must be mounted between centers and a drive plate and lathe dog must be used. The centers must be aligned and the mandrel must be free of burrs. Mount the workpiece into a lubricated mandrel of the proper size by using an arbor press. Ensure that the lathe dog is secured to the machined flat on the end of the mandrel and not on the smooth surface of the mandrel taper If expansion bushings are to be used with a mandrel, clean and care for the expansion bushings in the same manner as a normal mandrel.
The figure below show Pulley mounted on Mandrel



Always feed the tool bit in the direction of the large end of the mandrel, which is usually toward the headstock end, to avoid pulling the work out of the mandrel. If facing on a mandrel, avoid cutting into the mandrel with the tool bit.

b) Tailstock Center

1. Reference the center of the tailstock when setting the tool.
2. Position the tip of the tool with the tailstock center.

Setting the tool to the center of the workpiece using the tailstock center.

(https://openoregon.pressbooks.pub/manufacturingprocesses45/chapter/unit-4-turning/)

Learning unit 6: Carry out lathe machine operations

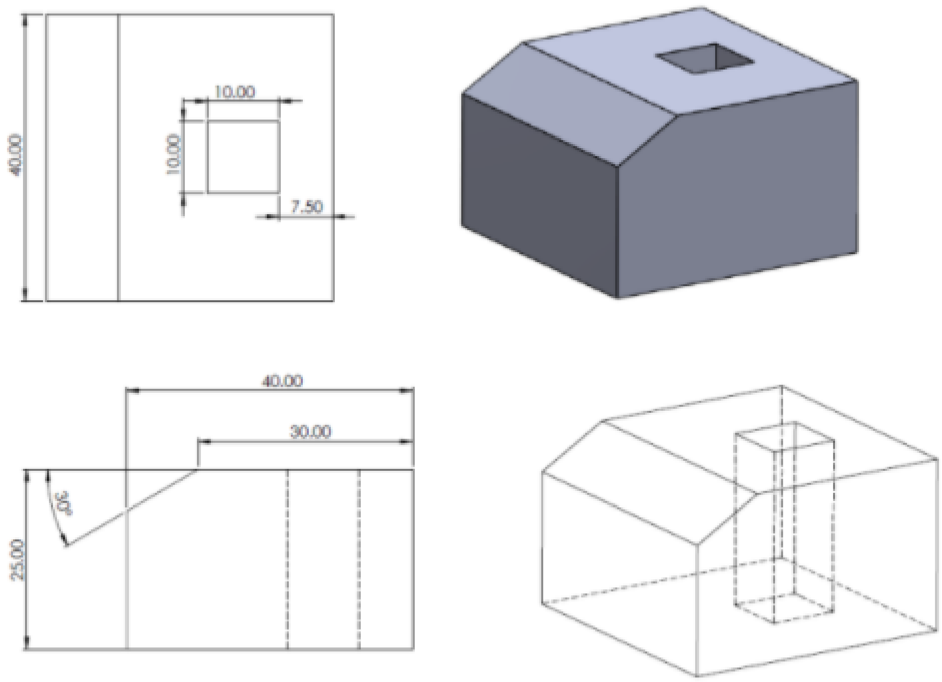
L O 6.1 Turn the workpiece

- **Content/Topic 1: Elements of Working Sheet**

a) Workpiece sketch

In Figure below a steel workpiece it must be machined from a cube 50mm on each side. Develop a plan containing the major machining processes to machine all surfaces of the part. For each process operation) make a sketch containing the following. The sketches should follow the normal sequence of operations.

- ✓ The name of the operation
- ✓ Draw the workpiece in a way it corresponds after the operation
- ✓ Label the surfaces machined after the operation
- ✓ Show/sketch the cutting tool that machines the surface(s) Show all motions needed to generate the surface(s)
- ✓ Indicate the surfaces where the component will be clamped during each process.



b) Title block

The clear working space on the drawing sheet is obtained by drawing border lines. In general practice, more space is kept on the left side for filling or binding when necessary.
The title block is an important feature in the drawing because it gives all the informations of the prepared drawing. It is proved at the right hand bottom corner of the sheet.
A title block is a template for a sheet and generally includes a border for the page and information about the design firm, such as its name, address, and logo. The title block can also display information about the project, client, and individual sheets, including issue dates and revision information.
All the block should contains at least the following informations:

1. Drawing name
2. Drawing number.
3. Institution or company
4. Scale used
5. Projection Symbol
6. Author names
7. Initials with dates,
8. Checked standards and approved the drawing

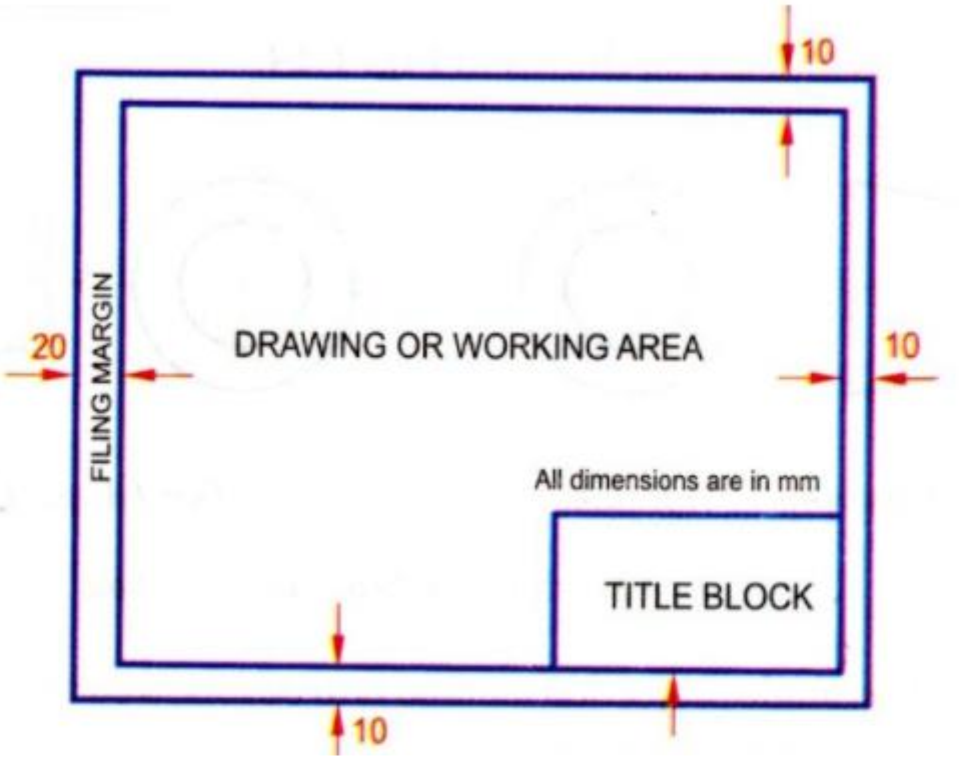


Figure 40: Drawing sheet

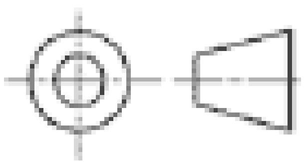
DRAWING TITLE	
	**AUTHOR NAME:**
	DATE:
	SCALE:
	DRAWING NUMBER:
	INSTITUTION OR COMPANY:
	CHECKED BY:

Figure 41: Title Block

- **Content/Topic 2: Turning Operations**

To perform different lathe machine operations on a lathe, the workpiece may be supported and driven by any one of the following methods:

- ✓ Workpiece held between centres and tool driven by carriers and catch plates.
- ✓ Workpiece held on a mandrel which is supported between centres and driven by carriers and catch plates.
- ✓ Held and driven by chuck with the other end supported on the tailstock centre.
- ✓ Held and driven by a chuck or a faceplate or an angle plate.

The above methods of holding the work may be classified under two heading:

- Workpiece held between centres.
- Workpiece held by a chuck or any other fixtures.

Following are the **Lathe machine operations** done either by holding the workpiece between centres or by a chuck:

- Turning Operation
    a. Plain or Straight Turning
    b. Rough Turning
    c. Shoulder Turning
    d. Taper Turning
    e. Eccentric Turning
        - Facing Operation
        - Chamfering Operation
        - Knurling Operation
        - Thread cutting Operation
        - Filing Operation
        - Polishing Operation
        - Grooving Operation
        - Spinning Operation
        - Spring Winding
- Forming

Lathe machine operations which are performed by holding the work by a chuck or a faceplate or an angle plate are:

- ✓ Drilling
- ✓ Reaming
- ✓ Boring
- ✓ Counterboring
- ✓ Taper boring
- ✓ Tapping
- ✓ Undercutting
- ✓ Internal thread cutting
- ✓ Parting-off

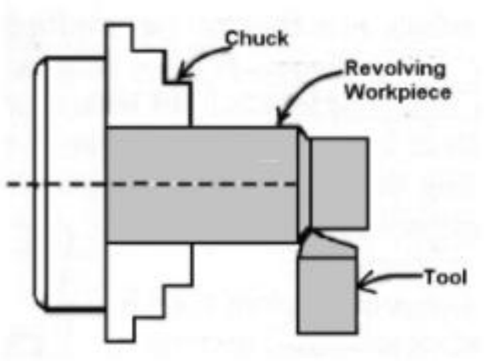
The operation which is performed by using special attachments are:

- ✓ Grinding
- ✓ Milling

Operations Done by Holding Workpiece between Centres

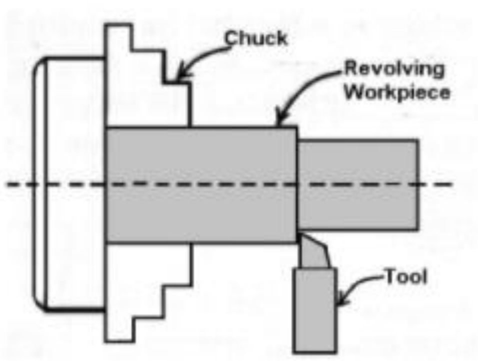
1. **Turning**

It is the most common type of operation in all lathe machine operations. Turning is the operation of removing the excess material from the workpiece to produce a cylindrical surface to the desired length.



The job held between the centre or a chuck and rotating at a required speed. The tool moves in a longitudinal direction to give the feed towards the headstock with proper depth of cut. The surface finish is very good.

1. Straight Turning:
The workpiece is held on the chuck and it is made to rotate about the axis, and the tool is fed parallel to the lathe axis. The straight turning produces a cylindrical surface by removing excess metal from the workpiece.
2. Rough Turning:
It is the process of removal of excess material from the workpiece in minimum time by applying high rate feed and heavy depth of cut. in rough turning the average depth of cut 2mm to 4mm can be given and feed is from 0.3 to 1.5mm per revolution of the work.
3. Shoulder Turning:
When a workpiece has different diameters and is to be turned, the surface forming steps from one diameter to the other is called the shoulder, and machining this part of the workpiece is called shoulder turning.



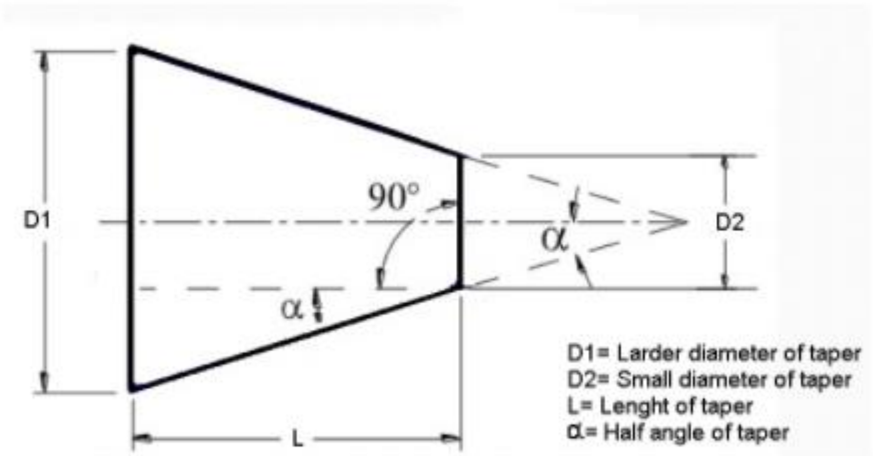
Eccentric turning:

When a cylindrical surface two separate axis of rotation, with the first axis, is offset to the other axis then such a workpiece is machined by the operation called eccentric turning. Here three sets of centre holes are drilled.

By holding the workpiece at these three centres the machining operation for each of the surface can be completed.

2. **Taper Turning**

- A ”taper” is the uniform increase or decrease in the diameter of the workpiece and measured along with its length.
- Taper turning means to produce a conical shape by a gradual reduction in diameter from a cylindrical workpiece.



The amount of taper in the workpiece is usually specified on the basis of the difference in diameter of the taper to its length. It is known as a cone and it is indicated by the letter K.

It has the formula K = D-d / 1 to produce the taper on the workpiece.

- D = Larger diameter of taper.
- d = Small diameter of taper.

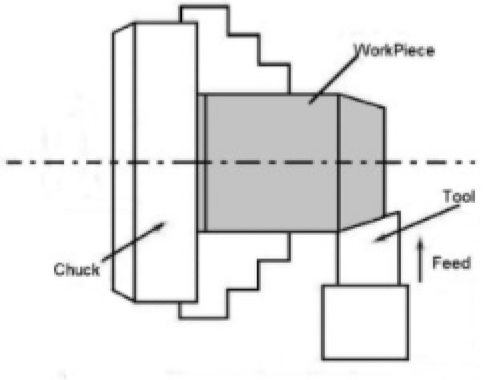
In the case of a lathe, the taper on a given workpiece is obtained by tuning the job and feeding the tool at an angle to produce a gradual increase or decrease in the diameter of the workpiece.

- The two important types of tapers are,
  - ✓ ”More taper” here, the angle is very small and varies from 1.4 to 1.5°.
  - ✓ ”Metric taper” is available in seven standard sizes with standard taper angles.
- Methods of taper turning,

- ✓ Form tool method
- ✓ Combined feeds method
- ✓ Compound rest method or swivelling compound rest method
- ✓ Tailstock set over method
- ✓ Taper turning attachment method

1. Form tool method

Here the taper length obtain is equal to the width of the form tool. To obtain the required size of the taper the form tool is fed slowly straight into the workpiece by operating the cross slide perpendicular to the lathe axis.

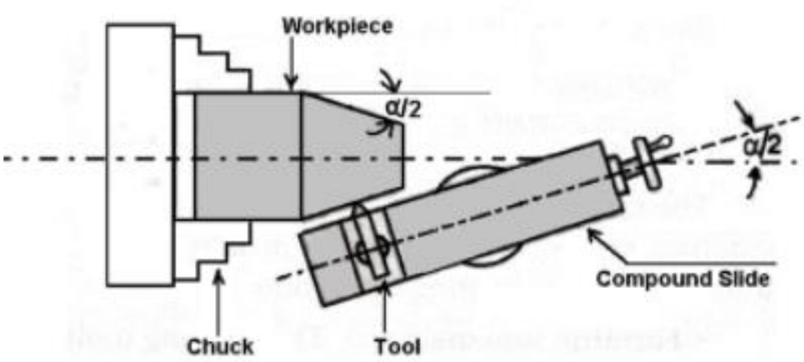


This is the simplest method of taper turning. It is limited to obtain small taper length such as chamfering the side of the workpiece. The method is done at a faster rate.

2. **Combined feeds method**

The combined feed is made with the movement of a tool in longitudinal and lateral direction simultaneously while moving the workpiece.

The taper, which we are going to obtain, is equal to the resultant to the magnitude of the longitudinal and lateral feeds. Changing the feeds rates in both directions can change the direction and the taper angle.



$$\tan\alpha = \frac{D_1 - D_2}{2L}$$

3. Compound rest swivel method

Here the workpiece rotates and the cutting tool is fed at an angle by swivelled compound rest. The base of the compound rest is graduated in degrees.

The taper angle is the angle at which the compound rest to be rotated is calculated by using the formula tanα = D-d / 21, where, D= bigger diameter, d = smaller diameter, l = length of the workpiece.

Compound rest can be swivelled to the required angle α. Once the compound rest is set to a particular angle then the tool is moved by compound rest and wheel.

4.Taper turning attachment method

- ✓ This method is similar to the compound rest method.
- ✓ Here the job or workpiece rotates and the tool is fed at the taper angle α.
- ✓ In this, arrangement, which has guide block graduated in degrees, with the help of this the block can be required taper angle to the lathe axis.
- ✓ The taper angle is calculated similarly to the compound rest method using the formula: tanα = D-d / 21.

Advantages of taper turning attachment:

- ✓ Internal tapers can be obtained accurately.
- ✓ Large size tapers can be easily obtained.
- ✓ Once the attachment is set the taper turning operation can do at a faster rate.
- ✓ By setting the taper angle to 'zero' we can carry out plain turning.

Disadvantages of taper turning attachment:

- ✓ It requires additional mounting facilities.
- ✓ Fitting and removing attachment consume more time.
- ✓ The attachment has to take large forces.

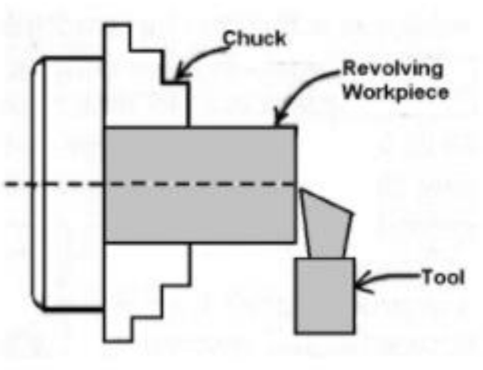
Tailstock set over method

Here the workpiece on the job is tilted at the required taper angle. The tool is fed parallel to the axis.

The tilting of the workpiece or the job to the required taper angle is achieved by the movement of the tailstock with the help of tailstock set over the screw. This method is useful for small tapers.

3. Facing

It is an operation of reducing the length of the workpiece by feeding the perpendicular to the lathe axis. This operation of reducing a flat surface on the end of the workpiece. For this operation, regular turning tool or facing tool may use. The cutting edge of the tool should set to the same height as the centre of the workpiece.

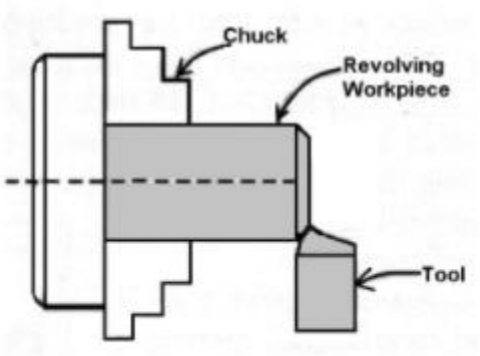


Facing consist of 2 operations

- ✓ Roughing: Here the depth of cut is 1.3mm
- ✓ Finishing: Here the depth of cut is 0.2-0.1mm.

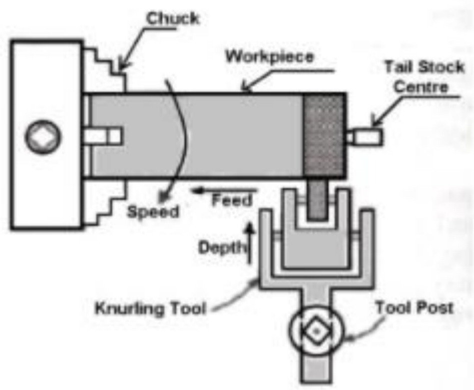
4. Chamfering operation:

It is the operation of getting a bevelled surface at the edge of a cylindrical workpiece. This operation is done in case of bolt ends and shaft ends. Chamfering helps to avoid damage to the sharp edges and protect the operation getting hurt during other operations. Chamfering on bolt helps to screw the nut easily.



5. Knurling operation

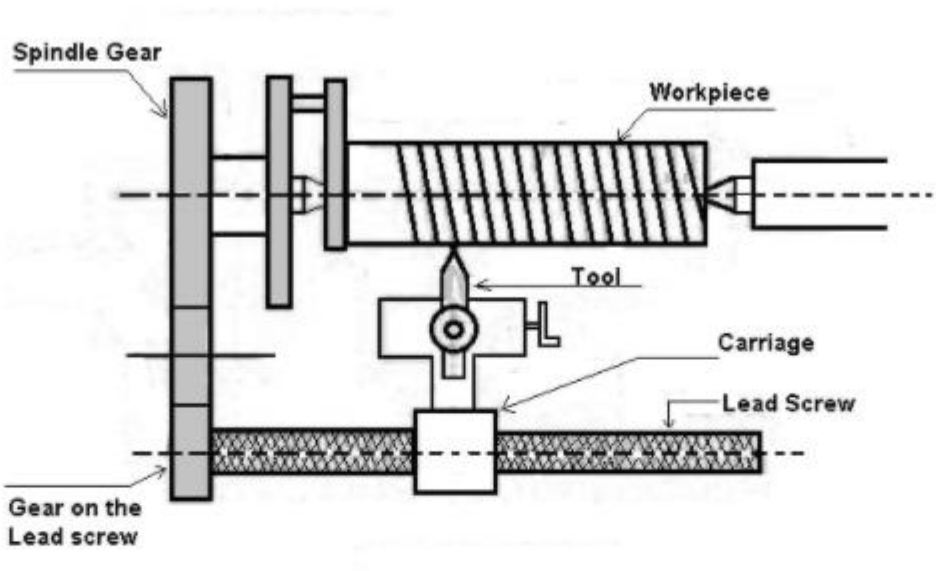
It is an operation of obtaining a diamond shape on the workpiece for the gripping purpose. This is done to provide a better gripping surface when operated by hands. It is done using a knurling tool. The tool consists of a set of hardened steel roller, and it is held rigidly on the toolpost.



Knurling is done at the lowest speed available on a lathe. It is done on the handles and also in case of ends of gauges. The feed varies from 1 to 2 mm per revolution. Two or three cuts may be necessary to give the full impression.

6. Thread cutting

It is the important operation in the lathe to obtain the continuous"helical grooves" or" threads''. When the threads or helical grooves are formed on the out surface of the workpiece is called external thread cutting. When the threads or helical grooves are formed on the inner surface of the workpiece is called internal thread cutting. The workpiece is rotating between the two centres i.e., live centre and dead centre on the lathe.



Here the tool is moved longitudinally to obtain the required type of the thread. When the tool is moved from right to the left we get the left-hand thread. Similarly, when the tool is moved from left to the right we get the right-hand thread. Here the motion of the carriage is provided by the lead screw. A pair of change gears drives the lead screw and by rotating the handle the depth of cut can be controlled.

7. **Filling**

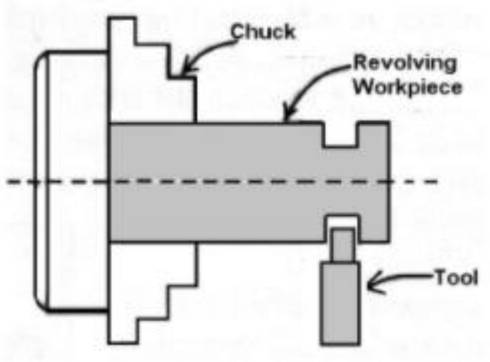
It is the finishing operation performed after turning. This is done on a lathe to remove burrs, sharp corners, and feed marks on a workpiece and also to bring it to the size by removing the very small amount of metal. The operation consists of passing a flat single-cut file over the workpiece which revolves at a high speed. The speed is usually twice that of turning.

8. **Polishing**

This operation is performed after filing to improve the surface quality of the workpiece. Polishing with successively finer grades of emery cloth after filing results in a very smooth, bright surface. The lathe is run at high speeds from 1500 to 1800m per min, and oil is used on the emery cloth.

9. **Grooving**

It is the process of reducing the diameter of a workpiece over a very narrow surface. It is done by a groove tool. A grooving tool is similar to the parting-off tool. It is often done at the end of a thread or adjacent to a shoulder to leave a small margin.



10. **Spinning**

It is the process of forming a thin sheet of metal by revolving the job at high speed and pressing it against a headstock spindle. Support is also given from the tailstock end.

11. **Spring Winding**

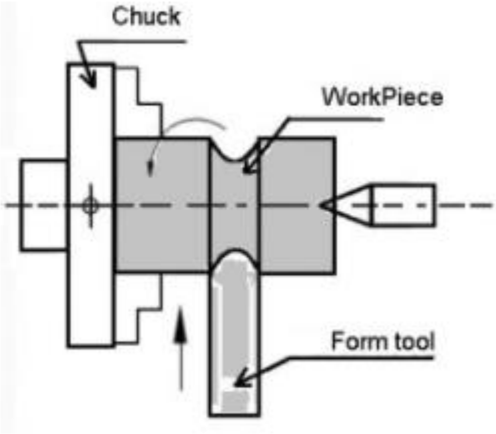
Spring winding is the process of making a coiled spring by passing a wire around a mandrel which is revolved on a chuck or between centres. A small hole is provided on the steel bar, which is supported by Tool Post and the wire is allowed to pass through it.

12. **Forming**

Forming tools are not supposed to remove much of the material and is used mainly for finishing formed surfaces. Generally, two types of forming tools are used straight and circular. Straight type is used for wider surface and the circular type for narrow surfaces.

It is the process of turning a convex, concave or of any irregular shape. Form-turning may be accomplished by the following method:

1. Using a forming tool.
2. Combining cross and longitudinal feed.
3. Tracing or copying a template.

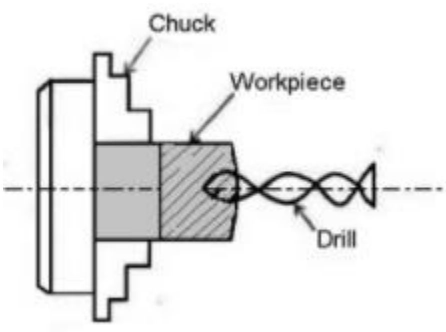


Lathe machine operations performed by holding the work by a chuck or a faceplate or an angle plate are

13. Drilling:

Drilling is the operation of producing a cylindrical hole in a workpiece. It is done by a rotating tool, the rotating side of the cutter, known as drilling drill. In this operation, The workpiece is revolving in a chuck or a faceplate and the drill is held in the tailstock drill holder or drill chuck.

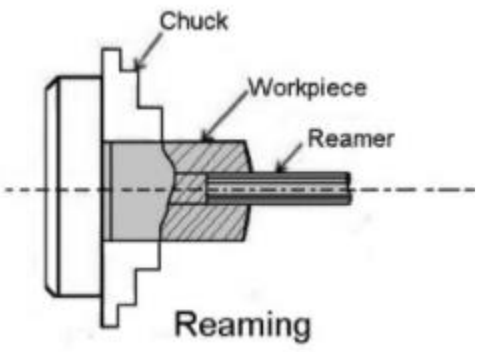
The feeding is adopted is affected by the movement of the tailstock spindle. This method is adopted for the drilling regular-shaped workpiece.



14. Reaming

Reaming is the operation of finishing and sizing a hole which has been already drilled or bored. The tool is used is called the reamer, which has multi-plate cutting edges.

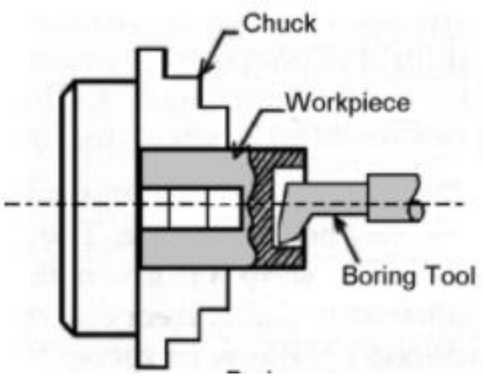
The reamer is held on the tailstock spindle, either directly or through a drill chuck and is held stationary while the work is revolved at a very slow speed.



15. Boring

Boring is the operation of enlarging the hole which is already drilled, punched or forged. It cannot produce a hole. Boring is similar to the external turning operation and can be performed in a lathe. In this operation, the workpiece is revolved in a chuck or a faceplate and the tools which are fitted to the tool post is fed into the work.

It consists of a boring bar having a single-point cutting tool which enlarges the hole. It also corrects out of roundness of a hole. This method adopted for boring small-sized works only. The speed of this process is slow.



16. Counterboring

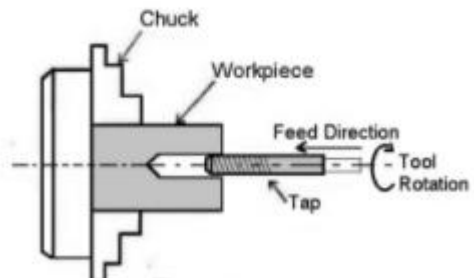
Counterboring is the operation of enlarging the end of the hole through a certain distance. It is similar to a shoulder work in external turning. The operation is similar to boring and plain boring tools or a counterbore may be used. The tool is used called a counterbore. The speed is slightly less than drilling.

17. Taper Boring

The principle of turning a tapered hole is similar to the external taper turning operation and is completed by rotating the work on a chuck or a faceplate. The feeding tool is at an angle to the axis of rotation of the workpiece. A boring tool is mounted on the tool post and by swivelling the compound slide to the desired angle, a short taper hole is machined by hand feeding.

18. Tapping

Tapping is the operation of cutting internal threads of small diameter using a multipoint cutting tool called the tap. In a lathe, the work is mounted on a chuck or on a faceplate and revolved at a very slow speed. A tap of required size held on a special fixture is mounted on the tailstock spindle.



Tapping

19. Undercutting

Undercutting is similar to grooving operation when performed inside a hole. It is the process of boring a groove or a large hole at a fixed distance from the end of a hole.

This is similar to the boring operation, except that a square nose parting is used. Undercutting is done at the end of an internal thread or a counterbore to provide clearance for the tool or any part.

Lathe Operations Done By Using Special Attachments

Lathe machine operations are performed by using special attachments:

20. Milling

Milling is the operation of removing metal by feeding the work against a rotating cutter having multiple cutting edges. For cutting keyways or grooves, the work is supported on the cross-slide by a special attachment and fed against a rotating milling cutter held by a chuck. The depth of cut is given by vertical adjustment of the work provided by the attachment. The depth of cut is given by vertical adjustment of the work provided by the attachment. The feeding movement is provided by the carriage and the vertical movement of the cutter is arranged in the attachment.

21. Grinding

Grinding is the operation of removing the metal in the form of minute chips by feeding the work against a rotating abrasive wheel known as the grinding wheel. Both internal and external surface of a workpiece may be ground by using a special attachment mounted on the cross slide. For the grinding external surface, the work may be revolved between centres or on a chuck. For internal grinding, the work must be revolved on a chuck or faceplate. The feeding is done by the carriage and the depth of cut is provided by the cross slide. Grinding is performed in a lathe for finishing a job, sharpening a cutter, or sizing workpiece after it has been hardened.

(https://www.theengineerspost.com/lathe-machine-operations/)

(Dwivedi, 2009)
(https://openoregon.pressbooks.pub/manufacturingprocesses45/chapter/unit-4-turning/)

LO 6.2: Check the workpiece

- **Content/Topic 1: Tips to consider when checking specifications**

a) Work Dimensions

While checking the dimensions of the work for external, internal diameter, depth and pitch first you need the following measurement instruments for dimensions:

- Vernier caliper
- Tape measure
- Micrometer
- Pitch gauge
- Taper gauge

1. Checking internal, external diameter and Depth

A Vernier caliper is a precision instrument that measures internal dimensions, outside dimensions, and depth. It can measure to an accuracy of one thousandth of an inch and one hundredth of a millimeter. The caliper has two sets of jaws, one each on the upper and lower portions. Each set has a fixed jaw and a movable jaw. The upper set is designed to measure inside dimensions, while the lower is designed for outside dimensions. It also has a depth probe at the base or on the rear part, which functions as a depth measuring tool.

- **Measuring Inside Dimensions**

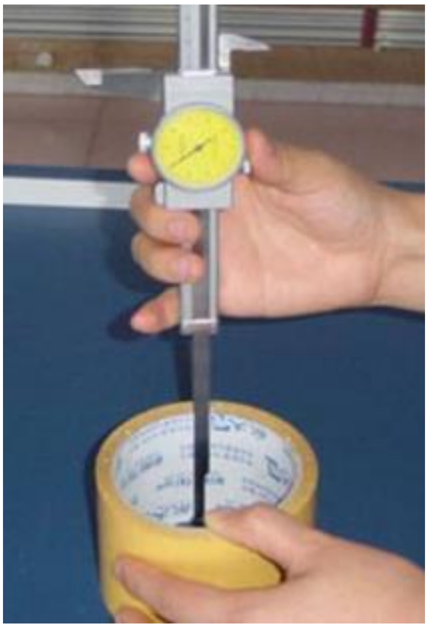
The upper set of jaws on the caliper can be used to measure inside dimensions, such as the diameter of a hole on a piece of wood or metal. Measuring the precise diameter of holes in pipes, cylinders, and other hollow objects is very important to many projects or applications. To get a precise measurement, the jaws will just be slid into the hole and the measurement taken from there. The caliper can also be used to measure holes of different shapes, e.g., square, rectangular, cylindrical, or hexagonal. Lastly, the upper jaws can be used to measure the distance between two objects, which can be done by putting the jaws between the objects.

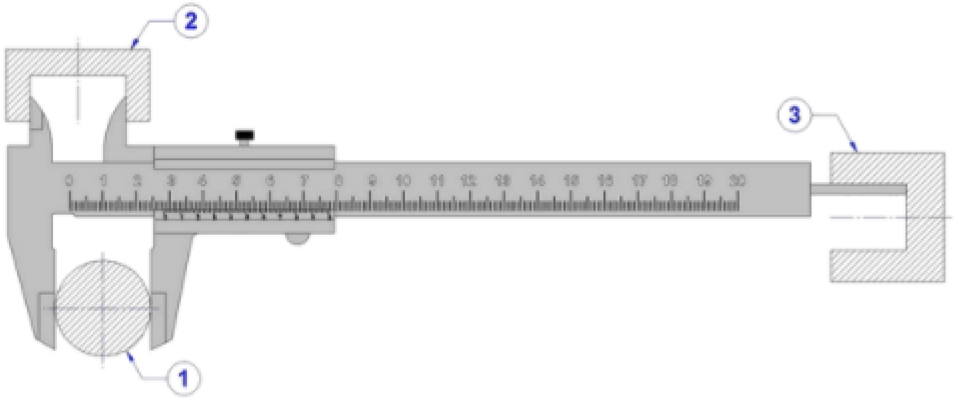
- **Measuring Outside Dimensions**

Outside dimensions include things such as the outer diameter of a cylinder and total length or width of an object. For measuring the outer diameter of something with the lower jaws, you will simply clamp them around the object. However, to measure length or width, you will place the object between the caliper jaws.

- **Measuring Depth**

As previously mentioned, the Vernier caliper has a depth probe on the rear part. This probe can be extended from the edge of the hole through to the other end for a measurement.



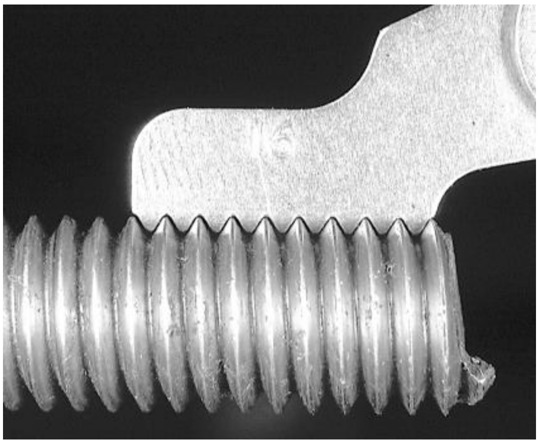


Measuring with a Vernier caliper

1. Measuring external dimensions
2. Measuring internal dimensions
3. Measuring depth dimensions

- **Checking of pitch**

When checking pitch the following instrument is needed to check the pitch of the threaded bolt like pitch screw.
The screw pitch gauge, which is a highly fool-proof, very effective and fairly accurate instrument used to identify or check the pitch of the threads cut on different threaded items. It consists of a case made of metal carrying a large number of blades or threaded strips which have teeth of different pitches, cut on their edges and markings corresponding to these pitches on their surfaces. In operation, different blades are applied or tried on the threads one after the other and when any one of them is found meshing with the cut teeth, the relevant reading is read directly from the marking on the matching blade surface. This gauge can be commonly used to measure or check the pitches of both external and internal threads. The free ends of the screw pitch gauge blades are generally made narrow for enabling them to enter the hollow parts easily while checking the internal threads. In some instruments, the blades are made to have markings both for the pitches as well as a value equal to double the depth of the threads. The latter quantity helps in determining quickly the drill size to be used before tapping.

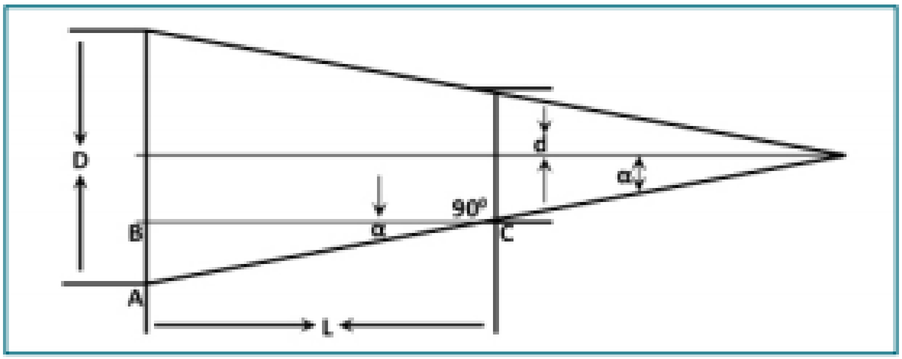


(i) Is used as a precision measuring instrument.
(ii) Allows the user to determine the profile of the given thread.
(iii) Allows to categorize the thread by shape and pitch.

b) Work Profile

- **Conicity of tapered holes Work piece**

The term conicity is amount of taper in a work piece usually specified by the ratio of the difference in diameters of the taper to its length. It's designated by the letter K. K = D – d/ L



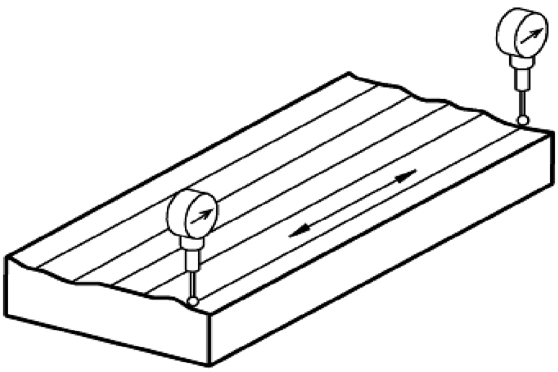
D = large diameter of taper in mm
d = small diameter of taper in mm
l = length of tapered part in mm
2α = Full taper angle
α = angle of taper or half taper angle

➢ Surface straightness

Straightness actually has two very different functions in GD&T depending on how it is called out. In its normal form or **Surface Straightness**, is a tolerance that controls the form of a line somewhere on the *surface* or the feature. **Axis Straightness** is a tolerance that controls how much curve is allowed in the part's *axis*. This is usually called out with an included call to maximum material condition. Both callouts are very different from each other.

The standard form of straightness is a 2-Dimensional tolerance that is used to ensure that a part is uniform across a surface or feature. Straightness can apply to either a flat feature such as the surface of a block, or it can apply to the surface of a cylinder along the axial direction. It is defined as the variance of the surface within a specified line on that surface.
It works the same way for holes. The hole below has a straightness callout below the size dimension. That means that the straightness tolerance applies to the axis of the hole.

The straightness tolerance may be used to control the straightness of a planar surface, a cylindrical surface, a center plane or a centerline. The straightness control as applied to a surface or a center plane is very similar. Perfect straightness occurs when all points of an element lie on the same line. Straightness is a form control. The straightness control how much each surface line element in a particular direction on a real part may vary from an ideal straight line. Orient the part in such a way as to minimize any out of parallel error. The surface should be as parallel as possible to the running axis of the dial indicator. Run the dial indicator along a line element in the direction indicated by the straightness control. Dial are placed in opposing positions. The dial indicators are used in combination to locate the center point.



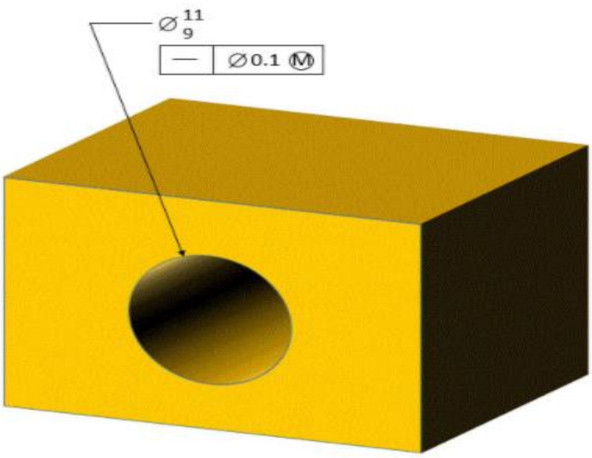


Figure 42: inspection straightness

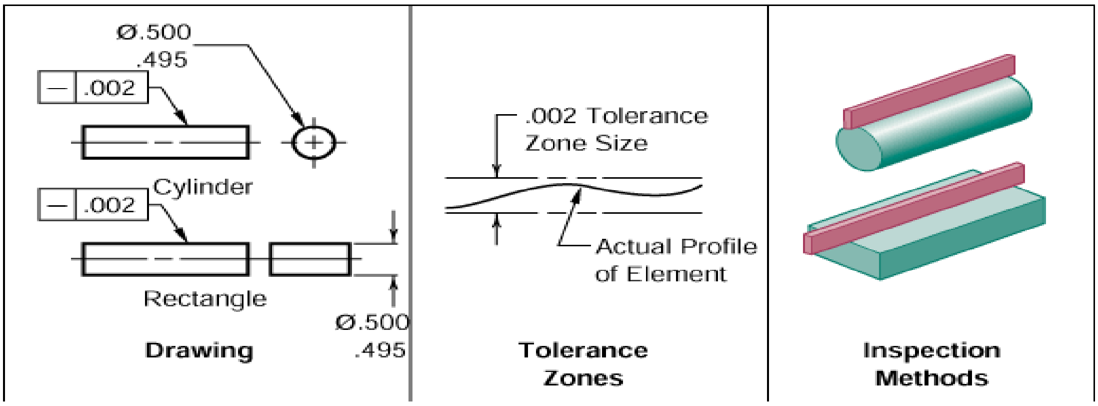


Figure 43: measuring Surface straightness

➢ **Work piece cylindricity**

Cylindricity is measured by constraining a part on its axis, and rotating it around while a height gauge records the variation of the surface in several locations along the length. The height gauge must have total variation less than the tolerance amount.

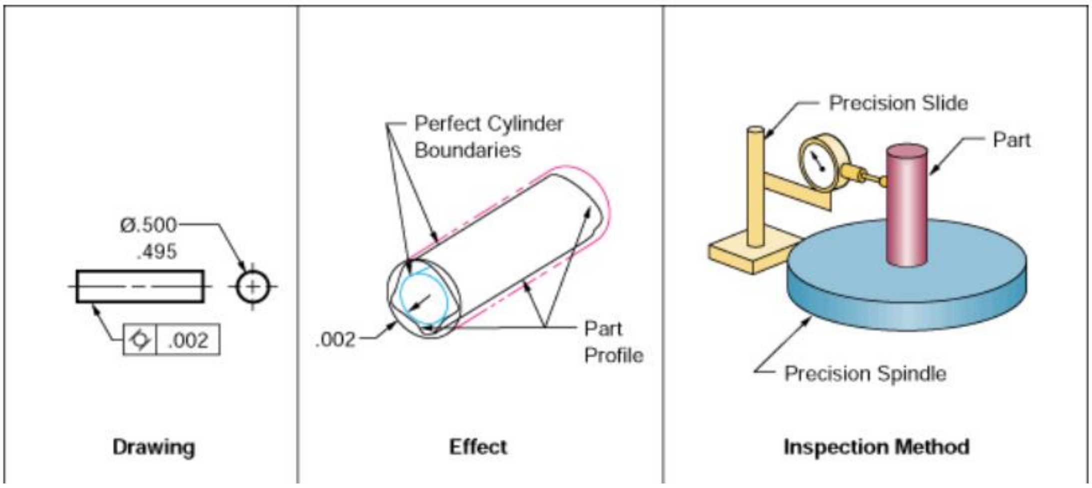


Figure 44.Work piece cylindricity

➢ **Grooves/recesses Concavity**

Internal recesses and surfaces often are incorrectly dimensioned. The use of the common axis as a datum line is the key to correct dimensioning. Figures 1 and 2 show a recessed groove as it is sometimes dimensioned. In Figure 1 dimensions A and B use a common axis, but dimension C uses the O.D. as a reference dimension. The recess diameter would include the tolerance allowed for dimension A, plus the tolerance on dimension C. This dimension would prove very difficult to measure. In Figure 2-dimension D is an extension of diameter B. The recess diameter would include tolerance for D added to the tolerance of B. This also would result in a difficult to measure dimension.

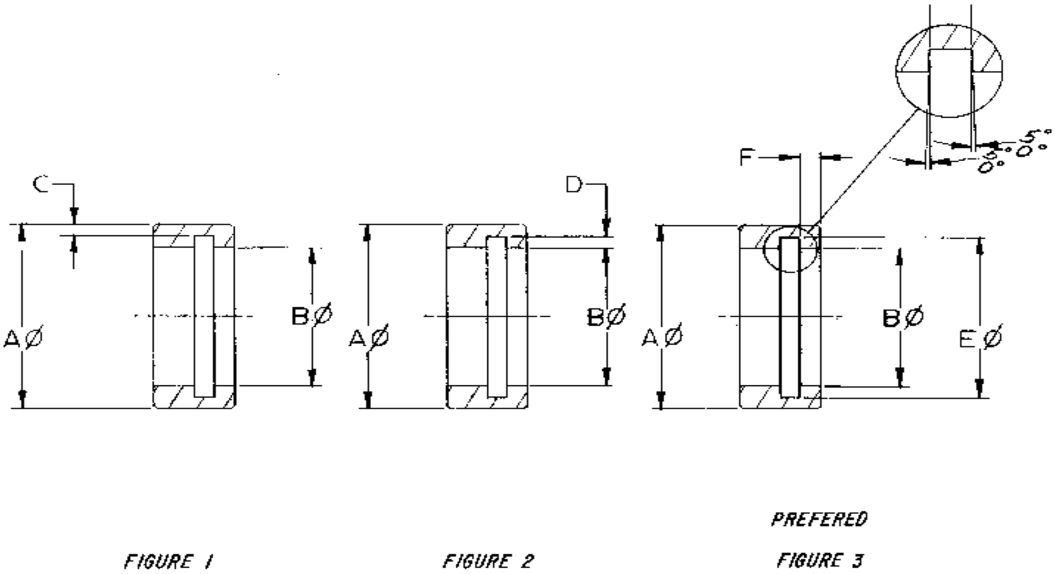
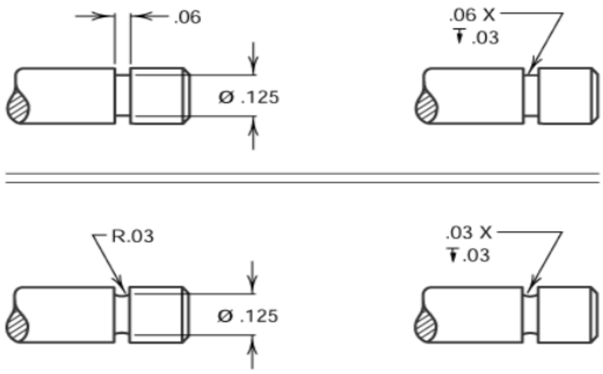


Figure 45.recesses Concavity



➢ **Surface finishing**

Roughness can be measured by manual comparison against a "surface roughness comparator" (a sample of known surface roughness), but more generally a surface profile measurement is made with a **profilometer**. Where **profilometers** use a probe to detect the surface, physically moving a probe along the surface in order to acquire the surface height. This is done mechanically with a feedback loop that monitors the force from the sample pushing up against the probe as it scans along the surface.

Surface **roughness** is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are great, the surface is rough, if they are small, the surface is smooth.

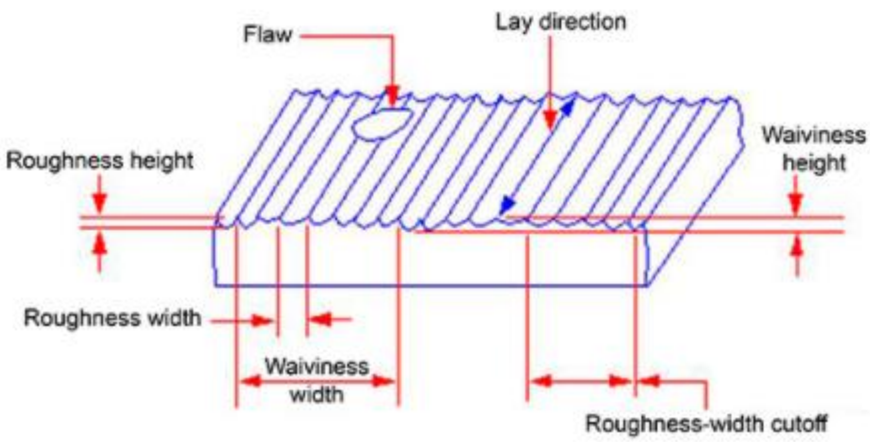


Figure 46: surface characteristics

To characterize the irregularities , some definite terms relating to the definite geometrical dimensions, are generally used in practice.they are

a) **Micro irregularities:** this nterm represent the finely spaced deviations which repeat itself throughout the surface. It may be longitudinal or transverse and generally occurs during the separation of chips.
b) **Macro irregularities:** these are the irregularities with respect to the longest concave or convex forms on surface. Lack of flatness, roundness are due to such faults.
c) **Surface waviness:** these are the regularly repeated wavy forms which occur usually due to machine tool fault. They are generaly evenly placed and can be again expressed as ratio of their pitch and height. It appears generally in turning due to tool chatter and feed.
d) **Surface flaws:** such irregularities occur at infrequent random intervals or more precisely it may occur at one or two places such as hole or peak or crack.

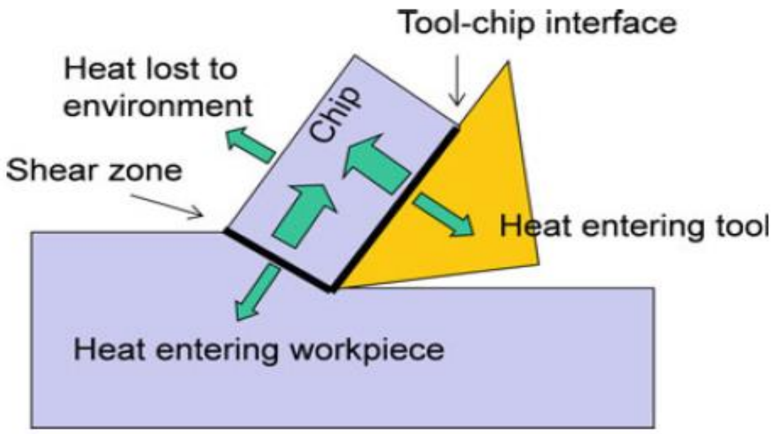
L O 6.3: Cool the tool and workpiece

- **Content/Topic 1: Cooling Techniques**

The temperature may damage the tool and the machined surface of the workpiece if it crosses a certain limit. It results in increased tool wear, lower part accuracy due to thermal expansion of part, and subsurface damage in the workpiece. Consequently, it is desirable that the heat is not conducted to the workpiece or the tool.

To prevent damage from high temperature, cutting fluids are used in various machining processes. A cutting fluid can reduce temperature by removing the heat from the heat generation zones. Additionally, it helps in reducing the friction at the tool-chip/tool-workpiece interface.

Hence, majority of metal cutting operations performed use cutting fluid. It also helps in chip removal in high-speed machining. Use of cutting fluid may help in increasing the material removal rate (MRR) by increasing depth of cut and/or cutting speed and improve tool life, surface finish, and dimensional accuracy. A wide range of cutting fluids is available for machining based on the application. The cooling capacity of the cutting fluid depends upon the properties of the base fluid and the volume, whereas, the chip removal capacity is based on the coolant application method and the operation geometry. The lubricating property of the cutting fluid is governed by chemical composition of the base fluid.



Cooling techniques

- Air cooling
- Fluid cooling

a) Air cooling

The friction and the temperature reached during the machining processes have been traditionally reduced by means of cutting fluids. In addition, they have other advantages as, for example: to remove the chips from the tool rake, to limit chemical diffusion, to reduce the tool wear and to protect the surface of the machined pieces from corrosion.

However, the use of cutting fluids involves some drawbacks such as their high costs, the risk to worker's health and environmental concerns. These drawbacks make necessary to develop and to apply new lubrication/cooling systems as an alternative to the traditional methods.

Among these new lubrication/cooling systems, it is possible to name: dry machining, minimum quantity lubrication, cryogenic refrigeration, solid lubricants and gaseous refrigeration.

In this work, the gaseous refrigeration systems are analysed. Namely, the cooling systems based on cold compressed air. The main reason to do it is the next one. Although these systems are not commonly used in manufacturing industry, commercial cold compressed air systems exist and they have become into a new and effective technique that allows: to reduce friction and heat in the cutting zone, to reduce the flank wear at high cutting speeds, to reduce the surface roughness and to increase the tool life during turning, milling and drilling processes carried out on hard-to-machining materials, as well as, to break the chip.

The present work collects a comparative review and analysis of the cooling system based on cold compressed air along with the main works about the application of such type of systems in machining processes.

Cooling systems based on cold compressed air

The cooling systems based on cold compressed air are included into the gaseous refrigerant group and represent an alternative to the lubrication/cooling conventional systems.

In cold compressed air systems, the air, once compressed, is cooled to decrease the temperature and to increase, in this way, its cooling capacity. This can be done by various means such as using liquid nitrogen, the vapor-compression refrigeration, the cooling by adiabatic expansion or cooling the air by a vortex tube.

This technique achieves temperatures in the cutting zone much lower than those obtained by dry machining. This makes that: cutting forces, particularly the force along the feed, are, also, significantly lower; the chips and their thicknesses are smaller; and the tool life increases, due to the less wear that is produced on it.

The specific heat of the air is about a quarter part of the specific heat of water. So, the heat capacity of air is smaller than the heat capacity of water and, for this reason, water is able to absorb more heat in comparison with air.
However, the air is shown as an efficient fluid for cooling at high working pressures because at these working conditions, its convection coefficient greatly increases. Due to this, the application of this device in machining processes as an alternative cooling system to the traditional flood systems is being investigated in the last years.

These researches have provided, among other more specific conclusions, that the cooling system with cold compressed air significantly reduces the heat generated in the cutting zone when it is compared with a dry cutting process and slightly less when it is compared with the cooling by flood; is able to extend the life of the cutting tool; and has a high environmental efficiency.

b) Fluid cooling

- **Mixed oil oils**

These oils are neat in so much as they are not mixed with water for the cutting operation.
They are usually a blend of a number of different types of mineral oil, together with additives for extreme-pressure applications. Neat cutting oils are used where severe cutting conditions exist, usually when slow speeds and feeds are used or with extremely tough and difficult-to-machine steels. These conditions require lubrication beyond that which can be achieved with soluble oils.
In some cases soluble oil cannot be used, due to the risk of water mixing with the hydraulic fluid or the lubricating oil of the machine. A neat oil compatible with those of the machine hydraulic or lubricating system can be used without risk of contamination.
Neat cutting oils do not have good cooling properties and it is therefore more difficult to maintain good dimensional accuracy. They are also responsible for dirty and hazardous work areas by seeping from the machine and dripping from workpieces and absorbing dust and grit from the atmosphere.
Low-viscosity or thin oils tend to smoke or fume during the cutting operation, and under some conditions are a fire risk.
The main advantages of neat cutting oils are their excellent lubricating property and good rust control. Some types do, however, stain non-ferrous metals.

- **Water Soluble oils**

Water is the cheapest cooling medium, but it is unsuitable by itself, mainly because it rusts ferrous metals. In soluble oils, or more correctly emulsifiable oils, the excellent cooling property of water is combined with the lubricating and protective qualities of mineral oil. Oil is, of course, not soluble in water, but with the aid of an agent known as an emulsifier it can be broken down and dispersed as fine particles throughout the water to form an emulsion.

Other ingredients are mixed with the oil to give better protection against corrosion, resistance to foaming and attack by bacteria, and prevention of skin irritations. Under severe cutting conditions where cutting forces are high, extreme-pressure (EP) additives are incorporated which do not break down under these extreme conditions but prevent the chip welding to the tool face.

Emulsions must be correctly mixed, otherwise the result is a slimy mess. Having selected the correct ratio of oil to water, the required volume of water is measured into a clean tank or bucket and the appropriate measured volume of soluble oil is added gradually at the same time as the water is slowly agitated. This will result in a stable oil/water emulsion ready for immediate use.

At dilutions between 1 in 20 and 1 in 25 (i.e. 1 part oil in 20 parts water) the emulsion is milky white and is used as a general-purpose cutting fluid for capstan and centre lathes, drilling, milling and sawing.

At dilutions from 1 in 60 to 1 in 80 the emulsion has a translucent appearance, rather than an opaque milky look, and is used for grinding operations.

For severe cutting operations, such as gear cutting or broaching and machining tough steels, fluids with EP additives are used at dilutions from 1 in 5 to 1 in 15.

As can readily be seen from the above, when the main requirement is direct cooling, as in the case of grinding, the dilution is greater, i.e. 1 in 80. When lubrication is the main requirement, as with gear cutting, the dilution is less, i.e. 1 in 5.

The advantages of soluble oils over neat cutting oils are their greater cooling capacity, lower cost, reduced smoke and elimination of fire hazard. Disadvantages of soluble oils compared with neat cutting oils are their poorer rust control and that the emulsion can separate, be affected by bacteria and become rancid.

- **Synthetic fluids**

Sometimes called chemical solutions, these fluids contain no oil but are a mixture of chemicals dissolved in water to give lubricating and anti-corrosion properties. They form a clear transparent solution with water, and are sometimes artificially colored.

They are very useful in grinding operations, where, being non-oily, they minimise clogging of the grinding wheel and are used at dilutions up to 1 in 80. As they are transparent, the operator can see the work, which is also important during grinding operations.

They are easily mixed with water and do not smoke during cutting. No slippery film is left on the work, machine or floor. They give excellent rust control and do not go rancid.

At dilutions of between 1 in 20 and 1 in 30 they can be used for general machining.

- **Petroleum-based oils**

Petroleum-based oil describes a broad range of natural hydrocarbon-based substances and refined petroleum products, each having a different chemical composition. As a result, each type of crude oil and refined product has distinct physical properties. These properties effect the way oil spreads and breaks down, the hazard it may pose to marine and human life, and the likelihood that it will pose a threat to natural and man-made resources.

Learning Unit 7 Clean and store tools, machine, materials and equipment

Learning Outcome 7.1: Clean machine, tools and equipment

- **Content/Topic 1: Cleaning Medium and Tools**

Cleaning medium and tools are very important in machining operation in order to make or to leave the machine safely even the material or equipment.

- ✓ **Soft brushes**

Ideal for light duty household, kitchen scrubbing and routine cleaning. It is also great for upholstery and vinyl. Easy to hold handle and firm bristles make this brush ideal for getting into tight cracks and crevices.

- ✓ **Soap solution**

a cleaning or emulsifying agent made by reacting animal or vegetable fats or oils with potassium or sodium hydroxide. Soaps often contain colouring matter and perfume and act by emulsifying grease and lowering the surface tension of water, so that it more readily penetrates open materials such as textiles

- ✓ **Solvent**

A solvent is a substance that dissolves a solute, resulting in a solution. A solvent is usually a liquid but can also be a solid, a gas, or a supercritical fluid.

Solvent cleaning is a cleansing process that uses chemical solutions to remove unwanted grease, oil, residue, coatings or paint from the surface of a material. There is more than one type of solvent, and each individual type may be better suited than another is to clean a specific type of base material.

Solvent cleaning is generally the first surface preparation method applied to the parts. Solvent cleaning removes release agents, such as silicone that may coat the part during molding, and any machine oil transferred to the part. Abrading surfaces coated with oil or grease drives the contaminants further into the parts, and chemical alteration of the surface is ineffective in the presence of contaminants.

- ✓ **Brooms**

Brooms and Brushes

Brooms are available in different widths and with different bristle types. Soft bristle brooms are usually better on indoor hard floors and hard bristles better on outdoor areas.

The wider the broom, the larger the area that can be swept in one pass.

Always choose the right type of mop for the task you will be doing. There are cotton mops, cotton/polyester blends, sponge mops, dust mops and microfiber mops. Cotton and cotton polyester blends come in different weights. Female staff may use a lighter one than a male. Cotton mops are used for mopping as they are more absorbent and cotton/polyester ones are used for applying polishes to hard floor because they are lint free and so do not leave particles. Microfibre mops do not require the use of any chemicals. Sponge mops are not recommended for commercial heavy cleaning as they disintegrate quickly.

Ideal when frequently applying floor finish. Heavy duty poly coated headband mesh withstands harsh chemicals and laundering for the life of the mop. Designed for high absorbency while allowing for quick release of floor finish. Available in narrow or wide band.

Wet mopping will remove any surface dirt and stains.

Half fill a mop bucket with hand hot water and add the correct amount of the selected detergent

- ✓ **Mops**

- ✓ **Clothes**

A basic general purpose cleaning cloth. White Microfiber cloths utilize microscopic micro-fibbers that remove virtually everything from a surface including biological contaminants. Use them damp or dry, with or without cleaning chemicals.

- **Content/Topic 2: Types of Cleaning**

A. Air pressure cleaning

Aspiration: is to suck in by inhaling or suck out material from a person's body. Using a suction syringe to clean out a newborn's nose is an example of aspirate. Aspirate is defined as to blow out air as you say the letter H. To pronounce the H in the word "huff" is an example of aspirate

Figure 47: Aspiration Machine

Cleaning blower is critical if furnace has a squirrel-cage fan, because openings in this type of blower often become clogged with dirt.

Air compressor: Is a cleaning equipment's mostly used to clean for complicated situation by using compressed air.

Figure 48: Air Compressor

A. Cleaning with cloth rugs

An important aspect of the cleaning process is the design of the cleaning machine. Mechanical methods, including moving the parts that are being cleaned, pumping the cleaning solution around them and spraying, high pressure, pressure flooding, brushing, ultrasound and electrolytic processes, can remove the laminar boundary layer on the surface of the work piece, significantly reduce the diffusion time and, therefore, accelerate the cleaning process considerably.

Dry water stains by blotting the rug with an absorbent cloth immediately to prevent water marks. Vacuum the rug regularly to keep dirt and debris from staining the fibers, if your rug has fringe, avoid vacuuming the fringe.

L O 7.2: Store tools, equipment and materials

- **Content/Topic 1: Housekeeping Basics**

➢ Overall cleanliness

Maintaining cleanliness is the essential part of healthy living because it is the cleanliness only which helps to improve our personality by keeping clean externally and internally. It is everybody's responsibility and one should keep themselves and their surroundings clean and hygienic.

Cleanliness means that there is no dirt, no dust, no stains, and no bad smells. The goals of cleanliness are health, beauty, absence of offensive odour and to avoid the spreading of dirt and contaminants to oneself and others.

With the help of cleanliness, we can keep our physical and mental health clean, which will make us feel good. Cleanliness gives rise to a good character by keeping body, mind, and soul clean and peaceful. Maintaining cleanliness is the essential part of healthy living because it is the cleanliness only which helps to improve our personality by keeping clean externally and internally.

It is everybody’s responsibility and one should keep themselves and their surroundings clean and hygienic. It also brings good and positive thoughts in the mind which slows down the occurrence of disease.

- **Adequate space and proper layout**

When planning the workshop layout, it is necessary to consider a number of factors that affect your work:

- ✓ What exactly do you want to do in the workshop: in order to make proper plan about required dimensions of the workshop and its organization, at first think about what are you going to use it for, what are your affinities, plans and working possibilities in the future;
- ✓ Estimate the costs and time required to equip the workshop: evaluate your options and what do you need for your workshop so it could become functional;
- ✓ You should plan the arrangement of the machines and worktables to ensure enough space to maneuver;
- ✓ The number of machines and workshop accessories (e.g. sawhorses, benches...);
- ✓ Calculate the number of workers / people in the workshop;
- ✓ Will you be making small objects such as toys and models, or you will manufacture large items such as doors and windows. This is very important when planning the space requirements, size of the machines, storage space for materials and finished products;
- ✓ Space for storing lumber and other materials for processing, and the storage of finished products;
- ✓ Room for the finish: it is smart to plan a separate room, where you can coat your products with protective oils, paints and lacquer. It should be dust free, with good ventilation for removing various vapors during the drying of coatings, and it should have enough space for comfortable work, because each scratch or blur is noticeable on the coating, and that can seriously reduce aesthetic value of your work;
- ✓ How easy is the access to the home workshop: The workshop should have direct entrance from the outside (not from the house), because it will often be necessary to carry in or out some large, heavy or dirty things, and a lot of waste as well. It may require access for the freight vehicle. Besides that, various works that produce noise, dust or unpleasant smells will be often made in the workshop, so it's good that the workshop is not located in the immediate area of the buildings where the people live;
- ✓ Are the doors of appropriate size for all your needs, so that machinery, lumber and finished products could pass through them;
- ✓ To prevent shop theft with the security measures related to the workshop, but, in the case of the high value machinery and products in the workshop, it should also be considered the business insurance.
- ✓ Are the heating / air conditioning, isolation and ventilation adequate;
- ✓ Is the plumbing and consequently the drainage of waste water needed for your workshop;
- ✓ Are there enough electrical circuits to supply your power needs;

- ✓ Quality lighting;
- ✓ Dust removing system.

- ➢ **Correct storage and materials handling**

What should your employees know before moving, handling, and storing materials?

In addition to training and education, applying general safety principles such as proper work practices, equipment, and controls can help reduce workplace accidents involving the moving, handling, and storing of materials. Whether moving materials manually or mechanically, your employees should know and understand the potential hazards associated with the task at hand and how to control their workplaces to minimize the danger.

Because numerous injuries can result from improperly handling and storing materials, workers should also be aware of accidents that may result from the unsafe or improper handling of equipment as well as from improper work practices. In addition, workers should be able to recognize the methods for eliminating or at least minimizing the occurrence of such accidents. Employers and employees should examine their workplaces to detect any unsafe or unhealthful conditions, practices, or equipment and take corrective action.

When moving materials manually, workers should attach handles or holders to loads. In addition, workers should always wear appropriate personal protective equipment and use proper lifting techniques. To prevent injury from oversize loads, workers should seek help in the following:

- ✓ When a load is so bulky that employees cannot properly grasp or lift it,
- ✓ When employees cannot see around or over a load, or
- ✓ When employees cannot safely handle a load.

Using the following personal protective equipment prevents needless injuries when manually moving materials:

- ✓ Hand and forearm protection, such as gloves, for loads with sharp or rough edges.
- ✓ Eye protection.
- ✓ Steel-toed safety shoes or boots.
- ✓ Metal, fiber, or plastic metatarsal guards to protect the instep area from impact or compression.

L O 7.3: Handle the product

- **Content/Topic 1: Tools and Products used for Metal Protection**

After finishing any operation on Lathe machine you have to clean all cutting tools used and you have to clean all part of machine even the workplace or the workshop then you apply oil in the moving parts against rust by using oil gun, soft brush. And clothes where necessary.

For the final product in order to make it safe against rust here we have six tips for preventing rust

Rust is the name for the orange-brown flakes of iron oxide that form on the surface of any metal containing iron that is exposed to air and water. It is a type of corrosion that can be highly destructive, as well as unsightly. In this article, we will share tips on how to prevent rust.

The rusting process begins when iron reacts with oxygen in the presence of water, saltwater, acids, or other harsh chemicals. As the iron oxide flakes off the metal surface, it exposes fresh iron molecules, which continue the reaction process. Eventually, large areas of rust form that may cause the entire metal structure to disintegrate.
The following are Tools and products used for metal protection:

- ✓ Oils
- ✓ Gun oil
- ✓ Greases
- ✓ Gun Grease
- ✓ Brushes

a. Oil

Machine oils lubricate machine parts to reduce friction between them and provide a layer of protection against corrosion. These multipurpose oils keep moving or threaded parts from sticking or binding and help reduce squeaks and other noises. Formulated specifically for use in machines, use these oils on moving parts such as castors, conveyors, small motors, hinges, fasteners, and fans.

b. Gun oil

An oil can (oilcan or oiler) is a can that holds oil (usually motor oil) for lubricating machines. An oil gun can also be used to fill oil-based lanterns. An occupation, referred to as an oiler, can use an oil can (among other tools) to lubricate some moving parts machinery.

c. Grease

A grease consists of an oil and/or other fluid lubricant that is mixed with a thickener, typically a soap, to form a solid or semisolid. Greases are usually shear-thinning or pseudo-plastic fluids, which means that the viscosity of the fluid is reduced under shear. The function of grease is to remain in contact with and lubricate moving surfaces without leaking out under gravity or centrifugal action, or squeezing out under pressure. The major practical advantage of grease is that it retains its properties under shear at all temperatures that it is subjected to during use.

d. Gun Grease

A grease gun is a common workshop and garage tool used for lubrication. The purpose of the grease gun is to apply lubricant through an aperture to a specific point, usually from a grease cartridge to a grease fitting or 'nipple'. The channels behind the grease nipple lead to where the lubrication is needed.

e. **Brushes**

Brushes is handled after any work on lathe machine it is used to remove all chips produced while performing different lathe operations in order to leave the machine clean after use.

- **Content/Topic 2: method of protecting the product**

Oiling and greasing are the method used to protect the final product after machining against rust.

- **Oiling**

Oiling is one of the best and conventional methods used to protect the metal from rust. As oil and water do not mix with each other, oiling forms a protective coating for the metal and hence prevent it from rusting. Oil can penetrate the oxide-water on the metal and stabilize it.

Figure 49: lubrication of moving part with oil

- **Greasing**

Grease is a semisolid lubricant. Grease generally consists of a soap emulsified with mineral or vegetable oil. The characteristic feature of greases is that they possess a high initial viscosity, which upon the application of shear, drops to give the effect of an oil-lubricated bearing of approximately the same viscosity as the base oil used in the grease. This change in viscosity is called shear thinning.

Greasing function

The function of grease is to remain in contact with and lubricate moving surfaces without leaking out under gravity or centrifugal action. Grease should retain its properties under shear at all temperatures that it is subjected to during use. Grease must be able to flow into the bearing through grease guns to all parts of the lubricated machinery as needed, but must not add significantly to power Requirements.

Grease characteristics

Cartridges improve storage (they prevent the grease from oozing out in high temperature conditions). Store cartridges upright in a cool, dry place. The operating instructions of the vehicle, machinery and Aggregate manufacturers must be observed! For further information see the technical information leaflet

Application:

For the lubrication and care of machines, plain bearings and anti-friction bearings, for long term lubrication in wet rooms and areas as well as in critical areas in the food, pharmaceutical, printing and paper industries. For lubricating points on commercial vehicles subject to medium or high loads, such as wheel bearings (axle bearings), driveshaft bearings, axle drives, trailer couplings, loading tailgates, wheel hubs, universal joints, steering knuckles, wheel suspensions, lifting gear, hand brake linkage, tipper bearings, semi-trailers, etc

- **Content/Topic 3: Product Storage defects**

  - **Effect of scratch**

Scratch behaviours of metallic and ceramic materials have been widely explore since the 1950's .However, fundamental scratch behaviour of polymeric materials has not been the focus of significant research until about a few years ago .Owing to the widespread uses of plastics in durable goods applications, and especially due to their soft surface nature, the scratch behaviour of plastics has drawn significant attention in recent years.

The effects of nano-additives on the scratch properties of epoxy(DER-332) have been examined. Scratch parameters such as critical load for onset of macro-crack formation, scratch coefficient of friction were utilized in this study while optical and electron microscopy was used to determine failure and fracture patterns caused by the scratch.

When subjected to scratch can depend on various factors. One of the most important of these factors is the physical and mechanical nature of the material, which itself can determine whether the surface damage will exhibit cracking, material removal, tearing, ductile drawing or etc. or even a combination of more than one feature. Therefore, when examining polymeric systems which do not exactly fall into either categories of ductile or brittle at testing temperatures, caution should be carried out especially while examining the damage type and extent and scale of occurrence.

  - **Effect of Heat and cold on finished product**

- Effect of heat generated on the workpiece
- Heat generated during machining could have both positive and adverse effects on the workpiece
- material. Heat generated during machining could result in the reduction of strength/hardness of
- the workpiece material, thereby lowered cutting forces. The reduction of cutting forces more
- often results a reduction of power consumption and an improvement in machinability of the
- workpiece material [14]. However, higher temperature at the cutting zone due to chemical
- reactivity of workpiece and cutting tool at high temperature, results in adhesion and diffusion
- wear [14]. Higher rate of heat is generated at the cutting zone during machining of metals and
- alloys with low thermal conductivity, this heat cannot be rapidly dispersed into the rapidly-

- moving chip. Higher temperature generation also affects the micro-structural constituents of the
- alloys, which may pose danger since the alloy is used for sensitive purposes [25][26]. One major
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- processes

Depletion of fossil resources in addition to their negative impact on the environment has accelerated the shift toward sustainable energy sources. Renewable energies such as solar radiation, ocean waves, wind, and biogas have been playing a major role in reforming the natural balance and providing the needs of the growing population demand. However, due to the climatic vagaries, the means of storing these types of renewable energy has become urgent. This has lead to a need to develop efficient and sustainable methods of storing energy.

Classification and Characteristics of Storage Systems

Due to intermittency in availability and constant variation in solar radiation, TES found its place in thermodynamic systems. TES not only reduces the discrepancy between the demand and supply by conserving energy, but also improves the performance and thermal reliability of the system. Therefore, designing efficient and economical TES systems is of high importance. However, few solar thermal plants in the world have employed TES at a large scale. Energy storage system can be described in terms of the following characteristics:

- Capacity defines the energy stored in the system and depends on the storage process, the medium, and the size of the system;
- Power defines how fast the energy stored in the system can be discharged (and charged);
- Efficiency is the ratio of the energy provided to the user to the energy needed to charge the storage system. It accounts for the energy loss during the storage period and the charging/discharging cycle;
- Storage period defines how long the energy is stored and lasts hours to months (i.e., hours, days, weeks, and months for seasonal storage);
- Charge and discharge time defines how much time is needed to charge/discharge the system; and
- Cost refers to either capacity (/kWh) or power (/kW) of the storage system and depends on the capital and operation costs of the storage equipment and its lifetime (i.e., the number of cycles).

The computational fluid dynamic approach is also a vastly used method to save money, where fluent software seems to be successfully used for different engineering applications.

The main types of thermal energy storage of solar energy are presented in Figure 1. An energy storage system can be described in terms of the following characteristics:

- **Capacity** defines the energy stored in the system and depends on the storage process, the medium, and the size of the system;
- **Power** defines how fast the energy stored in the system can be discharged (and charged);
- **Efficiency** is the ratio of the energy provided to the user to the energy needed to charge the storage system. It accounts for the energy loss during the storage period and the charging/discharging cycle;
- **Storage period** defines how long the energy is stored and lasts hours to months (i.e., hours,

- **Deformation**

Deformation is elongation or compressive, and we need to extend our concept of strain to include “shearing,” or “distortional,” effects. To illustrate the nature of shearing distortions, first consider a square grid inscribed on a tensile specimen as depicted in Fig. Upon uniaxial loading, the grid would be deformed so as to increase the length of the lines in the tensile loading direction and contract the lines perpendicular to the loading direction. However, the lines remain perpendicular to one another. These are termed normal strains, since planes normal to the loading.

Deformation processes transform solid materials from one shape into another. The initial shape is usually simple and is plastically deformed between tools, or dies, to obtain the desired final geometry and tolerances with required properties. A sequence of such processes is generally used to form material progressively from a simple geometry into a complex shape, whereby the tools represent the desired geometry and impart compressive or tensile stresses to the deforming material through the tool-material interface, for the cases of extrusion and deep drawing. Deformation processes are frequently used in conjunction with other unit operations, such as casting, machining, grinding, and heat treating, to complete the transformation from raw material to finished and assembly-ready discrete parts. Deformation processes, along with machining, have been at the core of modem mass production, because they involve primarily metal flow and do not depend on long-term metallurgical rate processes.

L O 7.4: Clean the workpiece

A) Oil removal techniques

In this oil removal treatment method, with the metal degreasing clean-out system of the first goal of the invention scheme of realization; Its step is as follows:

1. Earlier to be mixed into mass concentration be 5% solution with removing oil-bound distemper and water; Then, in this solution, add washing assistant again to be mixed with stand-by degreasing fluid. Washing assistant is 2: 5 with the ratio of removing oil-bound distemper.

2. The metallic surface for the treatment of oil removing with the pretreatment liquid spray is scrubbed the metallic surface then.

3. The metal that will spray, scrub with pretreatment liquid is placed in the degreasing fluid that step prepares in 1. and cleans.

4. The metal after will cleaning takes out, and is last with the water rinse that is not less than 50 ℃, eliminates metallic surface moisture.

A kind of metal degreasing clean-out system, this clean-out system includes sodium hydroxide, yellow soda ash and sodium phosphate. Clean-out system of the present invention is divided into pretreatment liquid and removes oil-bound distemper two portions:

The component of its pretreatment liquid is: sodium hydroxide 3～100g/L, sodium phosphate 30～50g/L, yellow soda ash 25～40g/L, trisodium phosphate 10～15g/L, water glass 5～10g/L, tripoly phosphate sodium STPP 5g/L, sodium sulfate 1g/L, EDTA disodium 1g/L, peregal (O-15) has 3～5g/L, and OP-10 has 2～3g/L, JFC 5～8g/L, sodium lauryl sulphate 10～12g/L, washing assistant 20mL.

B) Clean, dry floors to prevent slips and falls

Here are six guidelines to help you create a safer working environment for you and others

1. **Create Good Housekeeping Practices**
   Good housekeeping is critical. Safety and housekeeping go hand-in-hand. If your facility's housekeeping habits are poor, the result may be a higher incidence of employee injuries, ever-increasing insurance costs and regulatory citations. If an organization's facilities are noticeably clean and well organized, it is a good indication that its overall safety program is effective as well. Proper housekeeping is a routine. It is an ongoing procedure that is simply done as a part of each worker's daily performance. To create an effective housekeeping program, there are three simple steps to get you started.
2. **Reduce Wet or Slippery Surfaces**
   walking surfaces account for a significant portion of injuries reported by state agencies. The most frequently reported types of surfaces where these injuries occur include
   - ✓ Parking lots
   - ✓ Sidewalks (or lack of)
   - ✓ Food preparation areas
   - ✓ Shower stalls in residential dorms
   - ✓ Floors in general

Traction on outdoor surfaces can change considerably when weather conditions change. Those conditions can then affect indoor surfaces as moisture is tracked in by pedestrian traffic. Traction control procedures should be constantly monitored for their effectiveness.

3. **Avoid Creating Obstacles in Aisles and Walkways**
   Injuries can also result in from trips caused by obstacles, clutter, materials and equipment in aisles, corridors, entranceways and stairwells. Proper housekeeping in work and traffic areas is still the most effective control measure in avoiding the proliferation of these types of hazards. This means having policies or procedures in place and allowing time for cleaning the area, especially where scrap material or waste is a by-product of the work operation.
   - ✓ Keep all work areas, passageways, storerooms and service areas clean and orderly.
   - ✓ Avoid stringing cords, cables or air hoses across hallways or in any designated aisle.
   - ✓ In office areas, avoid leaving boxes, files or briefcases in the aisles.
   - ✓ Encourage safe work practices such as closing file cabinet drawers after use and picking up loose items from the floor.
   - ✓ Conduct periodic inspections for slip and trip hazards.

4. **Create and Maintain Proper Lighting**

   Poor lighting in the workplace is associated with an increase in accidents.

   - ✓ Use proper illumination in walkways, staircases, ramps, hallways, basements, construction areas and dock areas.
   - ✓ Keep work areas well lit and clean.
   - ✓ Upon entering a darkened room, always turn on the light first.
   - ✓ Keep poorly lit walkways clear of clutter and obstructions.
   - ✓ Keep areas around light switches clear and accessible.
   - ✓ Repair fixtures, switches and cords immediately if they malfunction

5. **Wear Proper Shoes**

   The shoes we wear can play a big part in preventing falls. The slickness of the soles and the type of heels worn need to be evaluated to avoid slips, trips and falls. Shoelaces need to be tied correctly. Whenever a fall-related injury is investigated, the footwear needs to be evaluated to see if it contributed to the incident. Employees are expected to wear footwear appropriate for the duties of their work task.

6. **Control Individual Behavior**

   This condition is the toughest to control. It is human nature to let our guard down for two seconds and be distracted by random thoughts or doing multiple activities. Being in a hurry will result in walking too fast or running which increases the chances of a slip, trip or fall. Taking shortcuts, not watching where one is going, using a cell phone, carrying materials which obstructs the vision, wearing sunglasses in low-light areas, not using designated walkways and speed are common elements in many on-the-job injuries.

C) Disposal of waste and recyclable materials

Metal scrap solution

One of the most efficient and common ways to deal with metal scraps is to sell them to another company and treat scrap metal as a revenue source. The following advice is helpful when choosing a metal recycler:

- ✓ Know the current market price so that your business gets a fair retur
- ✓ Ensure that recyclers provide complete records of all transactions with your business
- ✓ Confirm that recyclers use metal analysis equipment such as a spectrometer to verify the type and grading of metal(s) being recycled

On-site storage

Your company may need to keep hazardous waste products on site until they can be safely transferred elsewhere. If you are storing these materials on site, follow all safety regulations, which include the following:

- ✓ Use only approved containers and industry-accepted storage arrangements
- ✓ e copies of all Material Safety Data Sheets (MSDS) on site and keep them easily accessible
- ✓ Keep appropriate safety items in place, including spill kits, fire extinguishers and storage cabinets
- ✓ Have a secondary containment site in case of an emergency
- ✓ Ensure that products are properly labelled and secured

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