Ahsanullah University of Science and Technology (AUST)
Department of Mechanical and Production Engineering

LABORATORY MANUAL

For the students of

Department of Mechanical and Production Engineering

3rd Year, 1st Semester

Student Name :

Student ID :

Department of Mechanical and Production Engineering
Ahsanullah University of Science and Technology (AUST)

ME 3124: Manufacturing Processes Sessional

Credit Hour: 0.75

General Guidelines:

1. Students shall not be allowed to perform any experiment without apron and shoes.
2. Students must be prepared for the experiment prior to the class.
3. Report of an experiment must be submitted in the next class.
4. Viva for each experiment will be taken on the next day with the report.
5. The report should include the following:
    - Top sheet with necessary information
    - Main objectives
    - Work material/machine/tool/equipment used (with their specifications)
    - Experimental procedures
    - Experimental results and discussions (Experimental setup, Experimental conditions, Data, Graph, calculation etc.)
    - Conclusions
    - Acknowledgements
    - References
6. A quiz will be taken on the experiments at the end of the semester.
7. Marks distribution:

Total Marks		
Report	Attendance and Viva	Quiz
30	30	40

Experiment 01: A comprehensive study of the Lathe Machine: components, functions, and types of operations

Objectives:

- Become familiar with different components of lathe machine.
- Experiencing various types of turning operations in lathe machine.
- Learn to calculate cutting speed, material removal rate, and spindle horsepower.

Introduction:

A lathe machine is a versatile and widely used machine tool designed for shaping materials by rotating the workpiece against a cutting tool. Although traditionally employed for machining metals, modern lathes are now used to work with wood, plastics, composites, and various advanced materials due to their adaptability. In workshop practice, the term "lathe" is commonly used without further qualification, as its function is well understood, though more specific names—such as engine lathe, CNC lathe, or turret lathe—may be used depending on the model and application. These robust machines remove material through the controlled movement of cutting tools, which typically travel in linear or angular paths while the workpiece spins continuously. Through this process, lathes can produce precise cylindrical, conical, threaded, and contoured shapes used across numerous engineering and manufacturing applications.

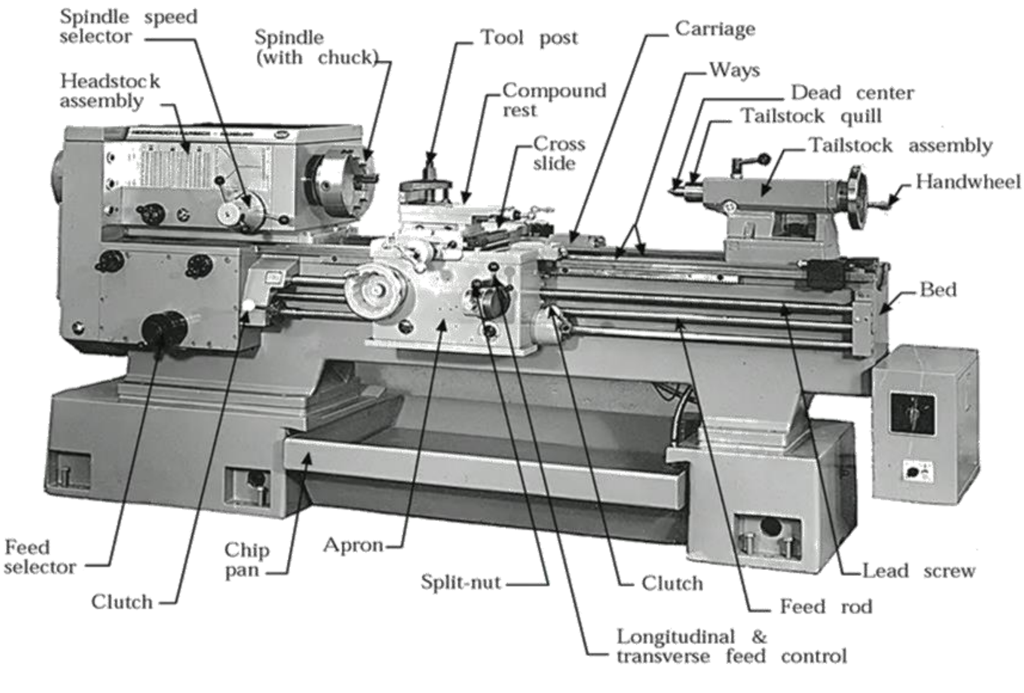


Figure1.1: Lathe Machine

Components of lathe machine:

Bed: All the main components are bolted on it including the headstock, tailstock, carriage etc. Usually made of cast iron due to its high compressive strength. Contains guide ways that guides the carriage and tailstock

Headstock: It provides the rotational power for the lathe's operations and holds the speed gear box, spindle, chuck, gear speed control levers, and feed controllers. It is usually Made up of cast iron

Figure 1.2: Headstock

Spindle: It is a hollow shaft on which the chuck is mounted and rotated. It is made from good quality alloy steel and is heat treated. Sometimes, Threads, tapers, etc. are made at one end of the spindle to which holding devices can be attached.

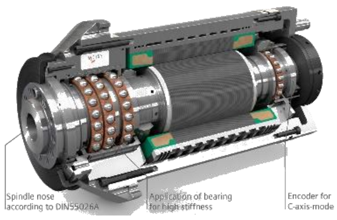


Figure 1.3: Spindle

Tailstock: It supports the loose end of the workpiece or a job while machining and hold the cutting tools such as drill chucks, drills, reamers etc. It can slide on the bed guideways and can be clamped in any position.

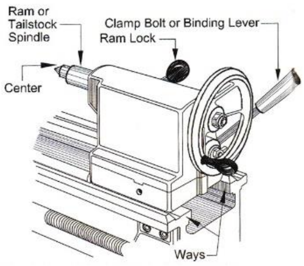


Figure 1.4: Tailstock

Carriage: It is located between headstock and tailstock and moves the tool post along the bed. Consists of 7 main parts – (i) Apron (ii) Saddle (iii) Cross slide (iv) Swivel plate (v) Compound Rest (vi) Top slide (vii) Tool post.

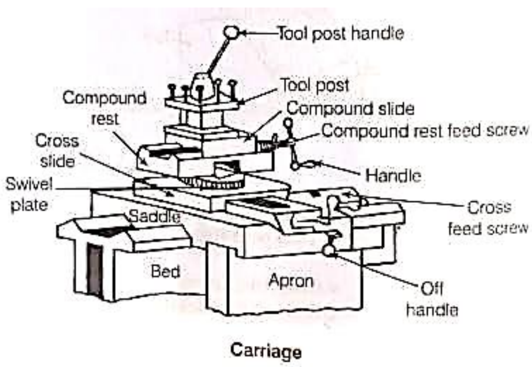


Figure 1.5: Carriage

Lead Screw and Feed Rod: These are responsible for transferring feed motion from feed gear box to carriage by engaging with carriage via apron. Lead screw is used for high feed rate operations like threading while feed rod is used for low feed rate operations like turning.

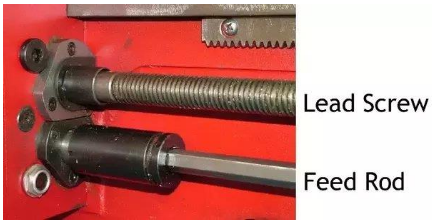


Figure 1.6: Lead screw and feed rod

Lathe Accessories

Chuck: A chuck in a lathe machine is a work-holding device used to securely grip and rotate the workpiece during machining operations. It is mounted on the spindle of the headstock and ensures that the workpiece stays firmly in place while the cutting tool removes material.

Figure: 4 jaw chuck

Figure: 3 Jaw Chuck

Figure: Collet Chuck

Figure1.7: Different types of chuck

Rest: It is used in machining long workpieces to prevent deflection while machining.

Figure: Steady Rest

Figure: Follower Rest

Figure 1.8: Different types of rest

Cutting speed:

It refers to the rate at which a point on the workpiece surface moves past the cutting edge of the tool, typically expressed in meters per minute (m/min). It can be determined using the formula given below.

$V = \pi DN/1000$ m/min

Where: N = Spindle Speed (RPM) , D = Diameter of Work piece (mm) , V= Cutting Speed of metal (m/min)

Types of gears used in Lathe:

Figure: Spur Gear

Figure: Double Cluster Gear

Figure: Triple Cluster Gear

Figure 1.9: Different types of gears used in Lathe machine

Different types of operations in lathe:

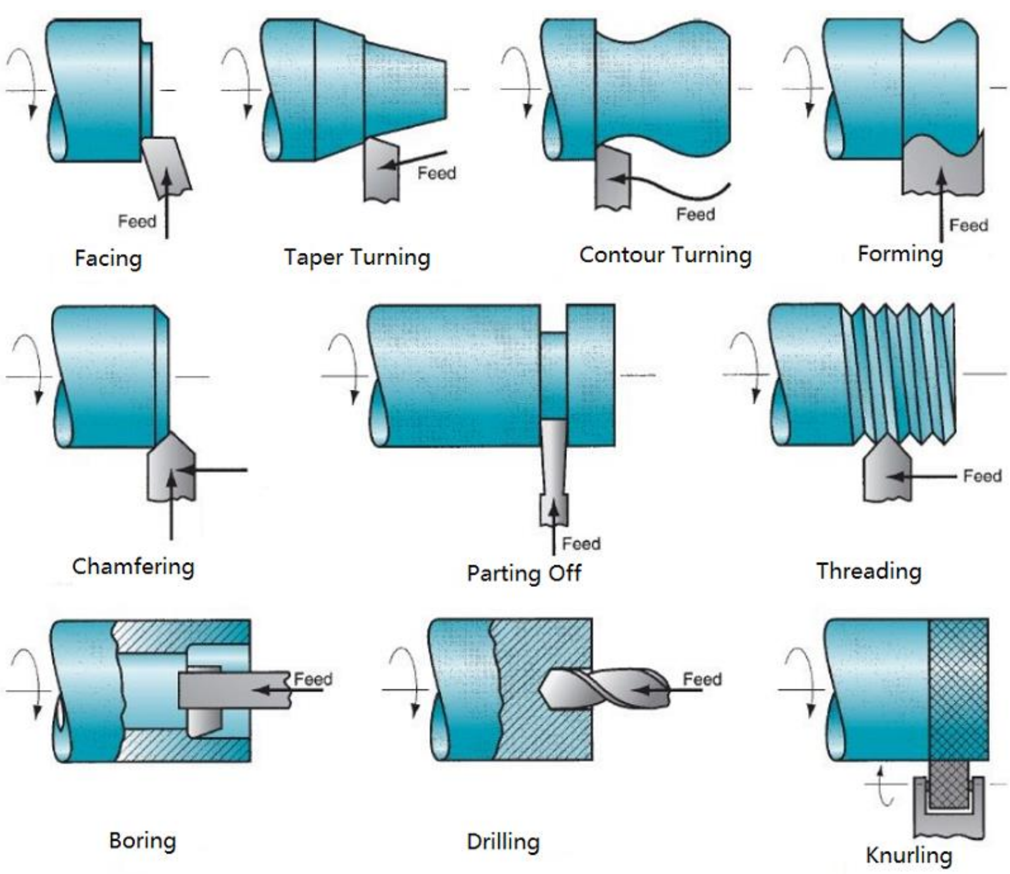


Figure 1.10: Different types of turning operations

Assignment:
i) Draw a flow chart that illustrate the transmission of power in an engine lathe
ii) Discuss the differences between turning and threading operations
iii) Explain the working principle of three jaw self-centering chuck.
iv) Explain the function of cutting fluid in a lathe machine.
v) Explain half- nut mechanism

Experiment 02(a): Study of Different Types of Milling Operations in order to Make a Part and Calculate the MRR

Objectives:

- Become familiar with basic milling operations
- Get firsthand experience at trying to maintain tolerances in machining.
- Learn to calculate cutting speed, material removal rate, spindle horsepower etc.
- Become familiar with different types of milling cutters.

Apparatus:

- Milling machine
- Vice
- Job
- Different types of milling cutters

Milling machine is one of the most versatile conventional machine tools with a wide range of metal cutting capabilities. Many complicated operations, such as indexing, gang milling, and straddle milling etc., can be carried out on a milling machine. Milling machines are among the most versatile and useful machine tools due to their capabilities to perform a variety of operations. Milling machines can be classified as horizontal and vertical.

Types of milling machine:

- Plain Horizontal Knee & Column Type Milling Machine
- Vertical Knee & Column Type Milling Machine
- Universal Horizontal Knee & Column Type Milling Machine
- Vertical and Ram-head (Omniversal) Milling Machine

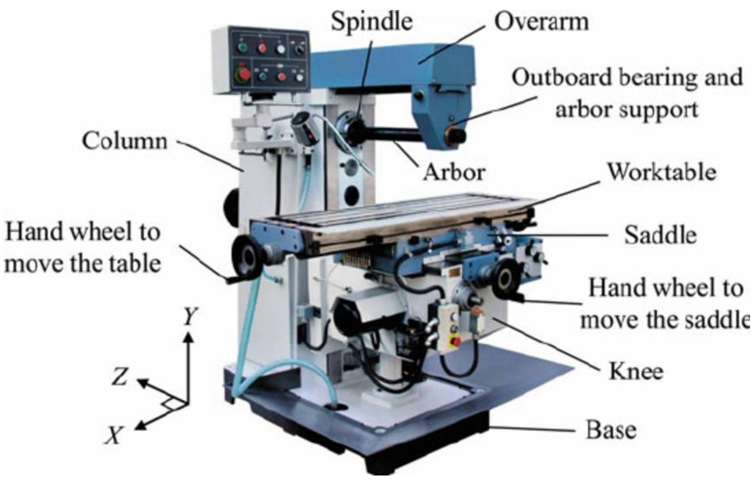


Figure 2.1: Parts of Milling Machine

Figure 2.2: Universal Horizontal Knee & Column Type Milling Machine

Figure 2.3: Dividing Head

Figure 2.4: Ram-head Milling Machine

Figure 2.5: Vertical knee & column Type Milling Machine

Parts of Horizontal Milling Machine:

- ✓ Column
- ✓ Knee
- ✓ Saddle
- ✓ Table
- ✓ Arbor

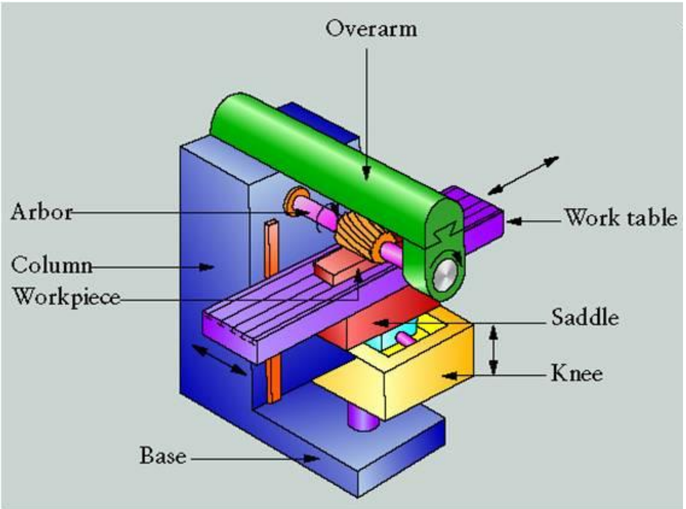


Figure 2.6: Horizontal Milling Machine

Parts of Vertical Milling Machine:

- Column
- Knee
- Saddle
- Table
- Milling head
- Ram

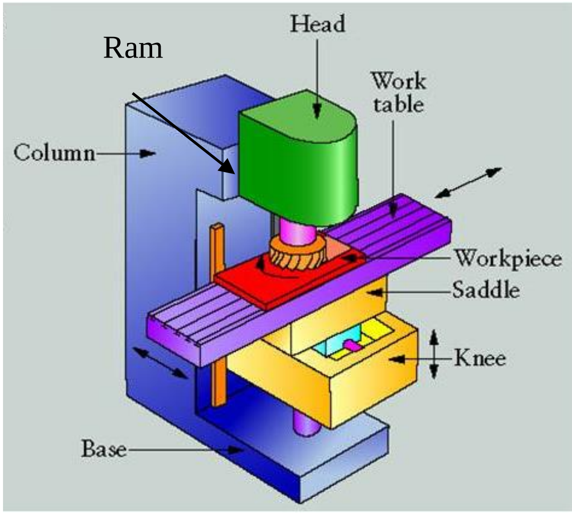


Figure 2.7: Vertical Milling Machine

Milling Cutters:

Figure 2.8: Different types of milling cutters

Methods of Milling

1. **Up Milling:** Up milling is also referred to as conventional milling. The direction of the cutter rotation opposes the feed motion. For example, if the cutter rotates clockwise, the workpiece is fed to the right in up-milling.

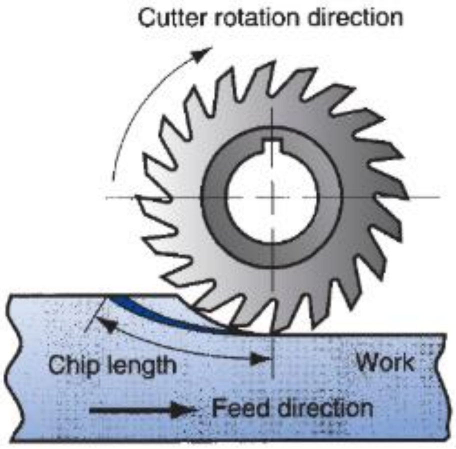


Figure 2.9: Up Milling

2. **Down Milling:** Down milling is also referred to as climb milling. The direction of cutter rotation is same as the feed motion. For example, if the cutter rotates counterclockwise, the workpiece is fed to the right in down milling.

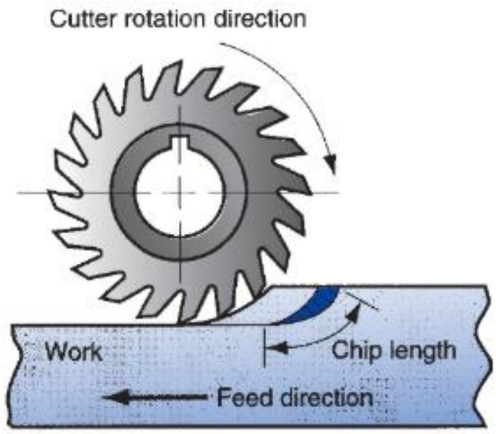


Figure 2.10: Down Milling

The chip formation in down milling is opposite to the chip formation in up milling. The figure for down milling shows that the cutter tooth is almost parallel to the top surface of the workpiece. The cutter tooth begins to mill the full chip thickness. Then the chip thickness gradually decreases.

Some Common Types of Milling Operations:

- **Peripheral Milling:** In peripheral milling, the milled surface is generated by teeth located on the periphery of the cutter body. The axis of cutter rotation is generally in a plane parallel to the workpiece surface to be machined. Slab milling, slotting, slitting, etc., are examples of peripheral milling.

- **Face Milling:** In face milling, the cutter is mounted on a spindle having an axis of rotation perpendicular to the workpiece surface. The milled surface results from the action of cutting edges located on the periphery and face of the cutter. Conventional milling, partial face milling, end milling, surface contouring, etc., are examples of face milling.

- **End Milling:** The cutter in end milling generally rotates on an axis vertical to the workpiece. It can be tilted to machine tapered surfaces. Cutting teeth are located on both the end face of the cutter and the periphery of the cutter body.

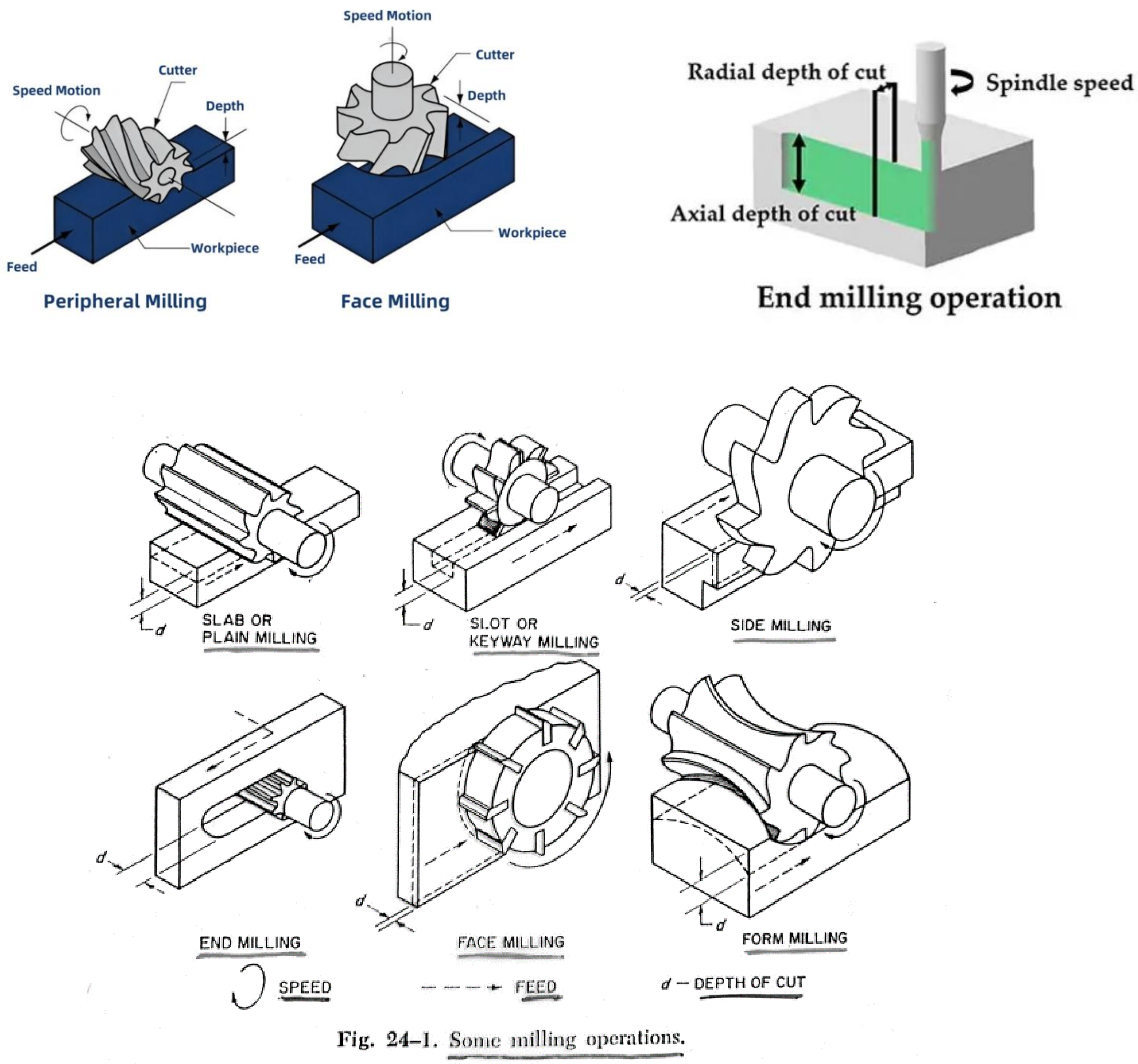


Figure 2.11: Different types of milling operations

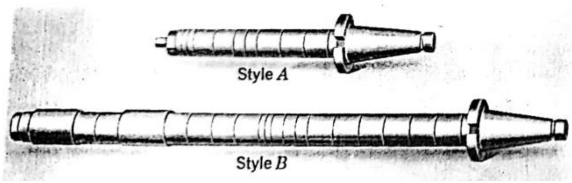


Figure 2. Arbors, styles *A* and *B* (Courtesy of Cincinnati Milacron).

Figure 2.12: Different types of arbor styles

Formulae Necessary for MRR Calculations:

Spindle Speed,

$$N = \frac{1000 \times V}{\pi D}$$

Where,

N = R.P.M. of the cutter

V = Linear cutting speed of the material in m/min.

D = Diameter of cutter in mm

Table feed rate,

$$f = f_t \cdot N \cdot n$$

Material removal rate, MRR

$$\text{MRR} = w \cdot d \cdot f$$

Where,

f = Table feed in mm/min

f_t = Movement per tooth of cutter in mm or chip load in mm/tooth

n = No. of teeth of cutter end

N = R.P.M. of the cutter

w = Width of cut

d = Depth of cut

Assignments:

- Differentiate between up milling and down milling. Which method do you think is more efficient?
- What are the functions of arbor and ram of a horizontal milling machine?
- Describe how cutters are mounted on the arbor of a horizontal milling machine.

Experiment 02(b): Study of Drilling Machine and its Operations to drill a Part and calculate the MRR

Objectives:

- Become familiar with different types of drilling machines.
- Master safe operation and proper setup of the drilling machine.
- Identify machine parts and perform basic operations.
- Define and correctly apply cutting parameters, calculate the Material Removal Rate (MRR).

Apparatus:

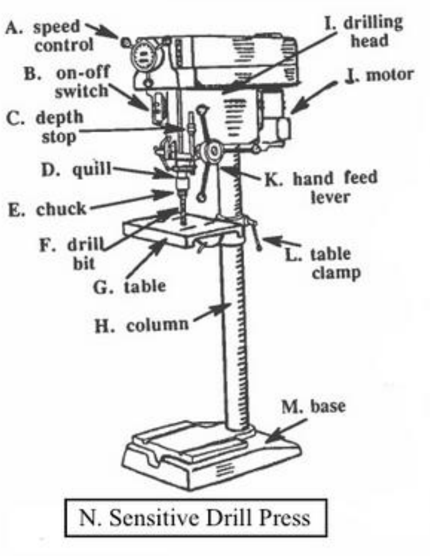
- Drilling machine
- Vice
- Job
- Different types of drill bits

A drill press is preferable to a hand drill when the location and orientation of the hole must be controlled accurately. A drill press is composed of a base that supports a column, the column in turn supports a table. Work can be supported on the table with a vise or hold down clamps or the table can be swiveled out of the way to allow tall work to be supported directly on the base. Height of the table can be adjusted with a table lift crank, then locked I place with a table lock. The column also supports a head containing a motor. The motor turns the spindle at a speed controlled by a variable speed control dial. The spindle holds a drill chuck to hold the cutting tools (drill bits, center drills, deburring tools, etc.)

Sensitive drill presses: used for precision drilling of small-diameter holes; hand feed only, allowing the operator to feel the cutting action and prevent breakage of delicate drill bits.

Radial drilling machines: used on large workpieces, spindle mounts on radial arm allowing drilling operations anywhere along the arm length.

Gang-drilling machines: independent columns each with different drilling operation work piece slide from one column to next



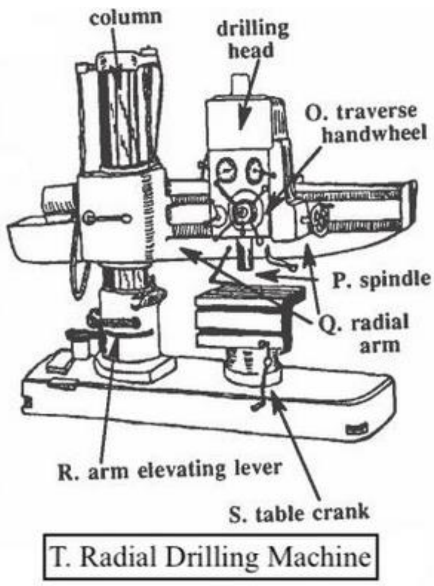


Fig: Gang-drilling machine

Fig 2.13: Different types of drilling machine

Drilling machines may be used for performing a variety of operations besides drilling a round hole.

1) Drilling produces a straight hole.
2) Countersinking produces a cone-shaped hole.
3) Reaming is used to finish a hole.
4) Boring is used to true and enlarge a hole.
5) Spot-facing produces a square surface.
6) Tapping produces internal threads.
7) Counterboring produces square shoulders in a hole.

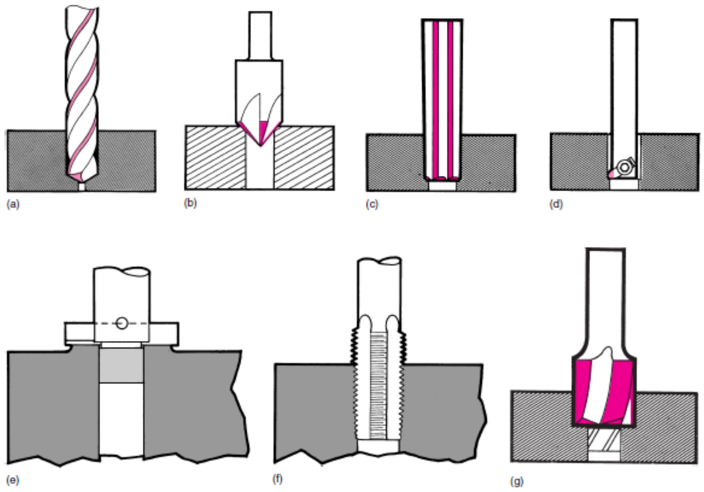


Fig 2.13: Different types of drilling operations

Formulae Necessary for MRR Calculations:

Spindle Speed,

$$N = \frac{1000 \times V}{\pi D}$$

Where,

N = R.P.M. of the cutter

V = Cutting speed of the material in m/min.

D = Diameter of Drill bit in mm

Material removal rate, MRR

$$\text{MRR} = \frac{\pi D^2}{4} \cdot f \cdot N$$

Where,

f = Feed in mm/min

N = R.P.M. of the cutter

D = Diameter of Drill bit in mm

Assignment:

a) Drilling can be done by a lathe machine, but can turning be done by a drill machine?

b) How can you sharpen the cutting edge of a drill bit?

Experiment 03(a): Study of different components and working principle of Grinding Machine

Objectives

1. To be familiar with the different components of the Grinding Machine
2. To be familiar with the working principle of Grinding Machine
3. To be familiar with the different operations that can be performed by using Grinding Machine

Apparatus:

➤ Grinding machine
➤ Grinding wheels
➤ Workpiece
➤ Vice

Introduction to Grinding Process and Grinding Machine:

Grinding is basically an abrasive machining process. Abrasive machining is the basic process in which chips are formed by very small cutting edges that is the integral part of the abrasive particles. The results that can be obtained from abrasive machining like grinding range from the finest and smoothest surfaces produced by any machining processes, in which very little material is removed, to rough, coarse surfaces and accompany high material removal rate (MRR). The abrasive particles may be (1) Free, (2) Mounted in resin on a belt, or (3) Close packed into wheels or stones, with abrasives held together by bonding material called bonded product. The metal removal process is basically the same in all three cases but with important differences due to spacing of active grains and degree of fixation of grains. Different types of abrasive machining includes:

➤ **Grinding:** It uses wheels as machining tool and provides accurate sizing, finishing and low MRR.
➤ **Abrasive Machining:** Its MRR is high and used to obtain desired shapes and approximate sizes.
➤**Snagging:** High MRR, rough rapid technique to clean up castings, forgings.
➤ **Honing:** "Stones" containing fine abrasives are used as tool, primarily a hole finishing process.
➤ **Lapping:** Fine particles embedded in soft metal or cloth; primarily a surface-finishing process.

An abrasive is hard and tough substance. It has many sharp edges. An abrasive cuts or wears away materials that are softer than it. So in abrasive machining abrasives are used as cutting tools or materials. The following figure shows an illustration of a typical grinding machine. The main parts of the machine are:

1. Base/Bed
2. Column
3. Saddle
4. Table
5. Wheel Guard

6. Wheal Head

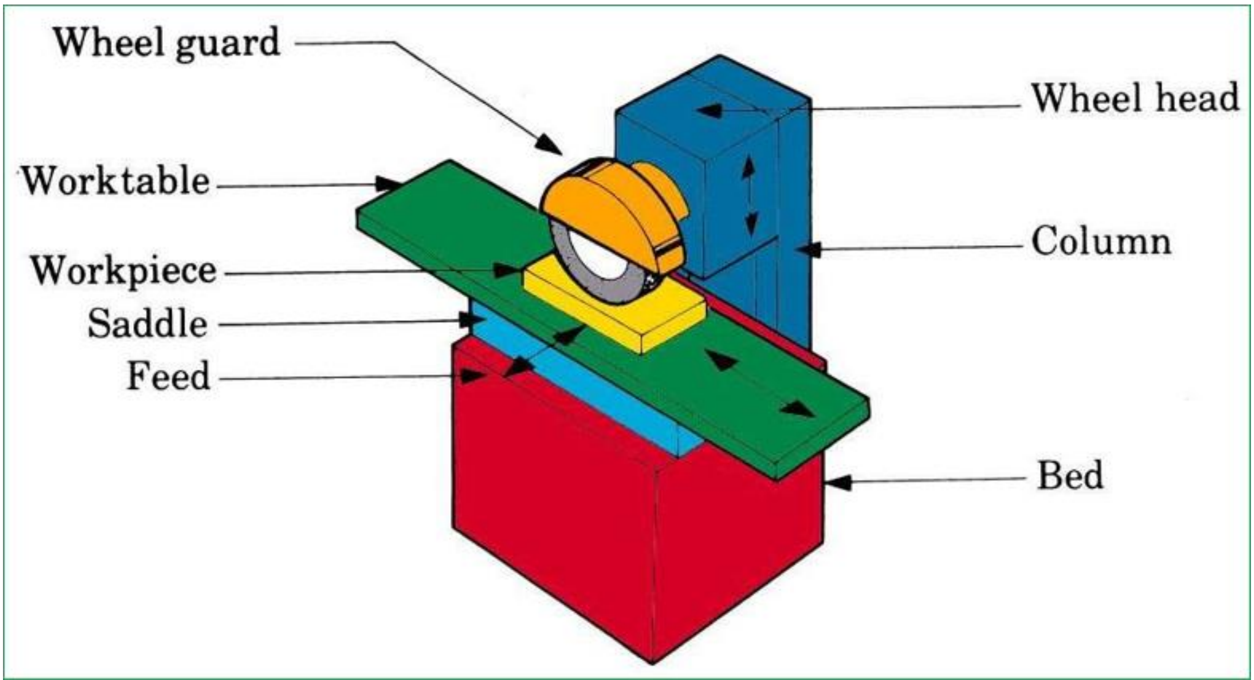


Fig 3.1: Schematic diagram of a grinding machine

Types of Grinding Wheel

All types of grinding machines use a grinding wheel made from one of the manufactured abrasives, silicon carbide or aluminum oxide. The wheel is manufactured by mixing selected sizes of abrasive granules with a bonding agent (such as clay, resin, rubber, shellac, or silicate of soda) and fusing them together by baking or firing. The grade (hardness) of a wheel is determined by the ratio of bond to abrasive. Properly, a grinding wheel is self-sharpening because as it is worked, the dull grains break off, exposing fresh, sharp grains. The harder the grade, the more slowly the wheel releases the grains.

The shapes that can be produced by machine grinding depend on the shapes that can be cut with a diamond or other "dresser" on the sides and edge of the grinding wheel and the way the workpiece is moved relative to the wheel. To grind a cylindrical form in a workpiece, the piece is rotated as it is fed against the grinding wheel. To grind an internal surface, a small wheel is so mounted that it can move back and forth inside the hollow of the workpiece, which is gripped in a rotating chuck.

Grinding wheels and their selection

A grinding wheel is made of abrasive grains held together by a bond. These grains cut like teeth when the wheel is revolved at high speed and is brought to bear against a work piece. The properties of a wheel that determine how it acts are kind and size of abrasive, how closely the grains are packed together and amount of the bonding material.

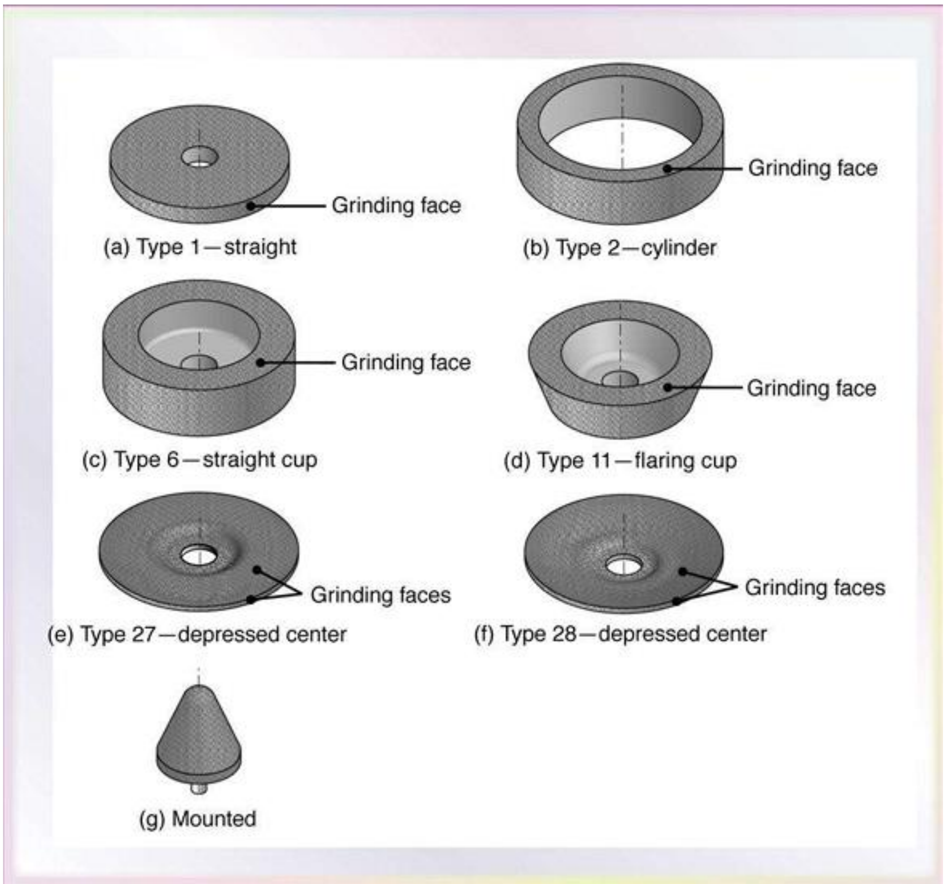


Fig 3.2: Common types of grinding wheels.

Cutting Action of Grinding Wheel

Each abrasive grain in a grinding wheel is a cutting tool. Each has sharp cutting edge which cutoff tiny particles from the metal being ground. The following figure shows a schematic view of cutting action by grinding wheel:

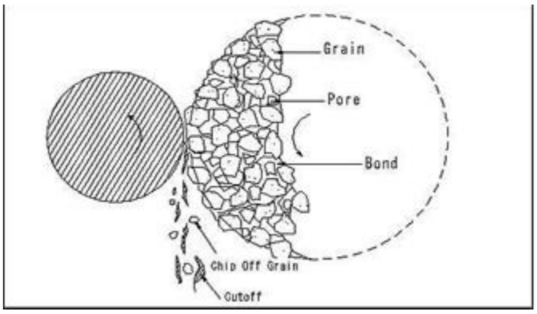


Fig 3.3: Cutting action of wheel

Types of Abrasive Grain

Two types of abrasives are used in grinding wheels: natural and manufactured i.e. artificial.

• **Natural abrasives:** The most commonly used natural abrasives are impure form of aluminum oxide called emery and corundum,
natural diamond.

• Except for diamonds, manufactured abrasives have almost entirely replaced natural abrasive materials. Even natural diamonds have been replaced in some instances by synthetic diamonds.

• The manufactured abrasives most commonly used in grinding wheels are aluminum oxide, silicon carbide, cubic boron nitride, and synthetic diamond.
The abrasive aggregate is selected according to the hardness of the material being cut.
• Aluminum oxide (A)
• Silicon carbide (S)
• Ceramic (C)
• Diamond (D, MD, SD)
• Cubic boron nitride (CBN)
Grinding wheels with diamond or CBN grains are called super abrasives.
Grinding wheels with aluminum oxide (corundum), silicon carbide, or ceramic grains are called conventional abrasives.

Grade of Wheel

The grade of a grinding wheel is a measure of the strength of the bonding material holding the individual grains in the wheel. It is used to indicate the relative hardness of a grinding wheel. Grade or hardness refers to the amount of bonding material used in the wheel, not to the hardness of the abrasive.
The range used to indicate grade is A to Z, with A representing maximum softness and Z maximum hardness. The selection of the proper grade of wheel is very important. Wheels that are too soft tend to release grains too rapidly and wheel wear is great. Wheels that are too hard do not release the abrasive grains fast enough and the dull grains remain bonded to the wheel causing a condition known as "glazing." From A (soft) to Z (hard), determines how tightly the bond holds the abrasive. A to H for softer structure, I to P for moderately hard structure and Q to Z for hard structure. Grade affects almost all considerations of grinding, such as wheel speed, coolant flow, maximum and minimum feed rates, and grinding depth.

Grain Spacing or Density

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.

Bond Material in Wheel

Abrasive grains are held together in a grinding wheel by a bonding material. The bonding material does not cut during grinding operation. Its main function is to hold the grains together with varying degrees of strength. Standard grinding wheel bonds are silicate, rubber and metal.

Working Principle

The process of grinding can take shape in many forms, but one of the oldest forms of grinding is the grinding ball mill. In this process, a hollow ball is used. Usually, the ball is made of metal, though it can be made of other material as well. Inside of the ball there is some form of grinding media. Grinding media is the material that is used to rise and fall inside of the ball. The fall of the grinding media is what causes the material to be ground. The types of grinding media that is used inside of the grinding ball will depend on the things that are being ground.

Classification of Grinding Operations

- **Rough Machining Operations**: On abrasive-machining operations, metal is removed more rapidly than on finish-grinding operations. It involves depth of cut 1.5 mm or more.
- **Finish Grinding**: On finish grinding operations, grinding wheels remove metal relatively slowly in comparison with other cutting tools. It usually follows rough-machining operations, and generally involves machining to very close tolerance. Three types of precision grinding exists

1. External cylindrical grinding
2. Internal cylindrical grinding
3. Surface grinding

Surface Grinding: It is most common oof the grinding operations. A rotating wheel is used in the grinding of flat surfaces. Types of surface grinding are vertical spindle and rotary tables.
Cylindrical Grinding: It is also called center-type grinding and is used in the removing the cylindrical surfaces and shoulders of the workpiece. Both the tool and the workpiece are rotated by separate motors and at different speeds. The axes of rotation tool can be adjusted to produce a variety of shapes.

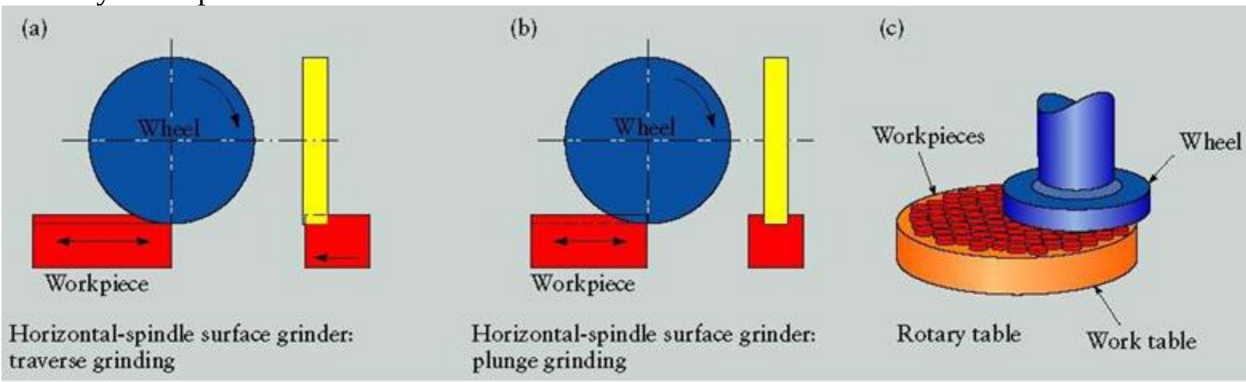


Fig 3.4: Different types of grinding operations.

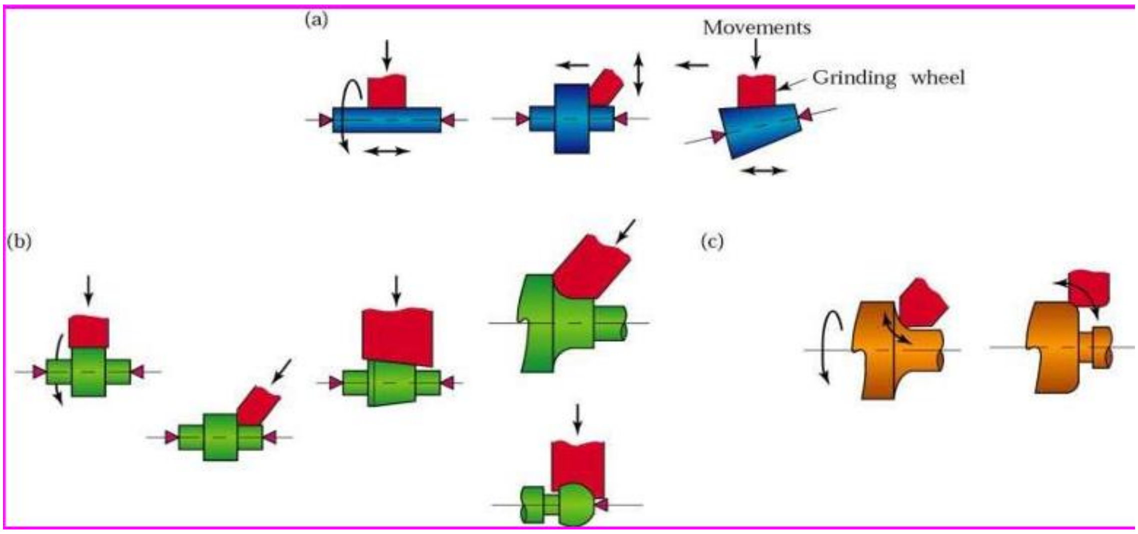


Fig 3.5: Examples of various cylindrical grinding operations. (a) Traverse grinding, (b) Plunge grinding, and (c) Profile grinding.

Internal Grinding: It is used to grind the inside diameter of the workpiece. Tapered holes can be ground with the use of internal grinders that can swivel on the horizontal.

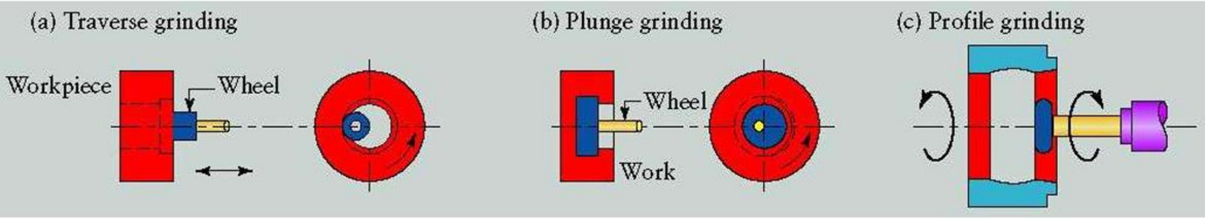


Fig 3.6: Schematic of Internal Grinding

Truing and Dressing of Grinding Wheel

Truing is a process used to correct an "out of round" condition in a grinding wheel by removing abrasive particles from the high parts of the wheel. This operation is also utilized to form the wheel into a specific shape, such as a concave or convex profile. To ensure the wheel is in good condition and runs true on both its periphery and sides, it should be trued each time it is mounted on the spindle.

Dressing is a process performed to restore the cutting ability of a grinding wheel whenever it becomes dull, loaded, or glazed from use. A dressing tool, typically a diamond tool, is used to remove the dull or loaded outer layer of the wheel, exposing fresh, sharp abrasive grains. This operation produces a sharp grinding surface and is necessary whenever the wheel cuts poorly, which often results in burning the workpiece.

Calculation of Grinding Ratio

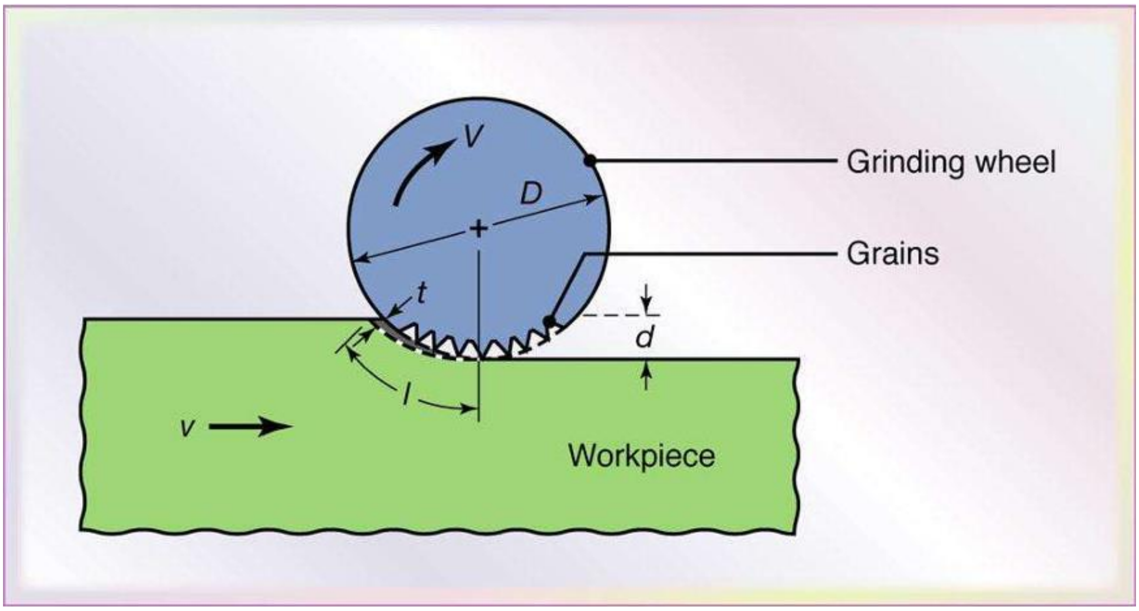


Fig 3.7: Calculation of grinding ratio

Here,

D=Grinding wheel diameter; d= wheel depth of cut; V= Tangential velocity; v=workpiece velocity; t= undeformed thickness (grain depth of cut)

Grinding Ratio, G = Volume of material removed / Volume of wheel wear

MRR = Volume removed / Machining time

$$= \frac{L \times w \times d}{t}$$

L= Length of grinding pass (mm); w = Width of Cut; d = Depth of Cut; t = Time (min)

ASSINGNMENTS

- Why is grinding an abrasive machining process?
- Differentiate between rough and finish grinding process.
- Why is dressing of wheel necessary for grinding? Explain.
- What do you understand by fracture resistance and wear resistance?
- Calculate the MRR of your machining operation.

Experiment 03(b): Study of different parts of shaper machine and its operation procedure and MRR calculation

Objectives

1. Understand the construction and working principle of a shaper machine.
2. Identify the major parts of a shaper and their functions.
3. Explain the quick return mechanism used in shaping operations.

Apparatus

1. Shaper Machine (Standard horizontal shaper)
2. Single-point cutting tool
3. Workpiece (mild steel / aluminum block)
4. Vernier caliper / steel rule
5. Machine vice
6. Safety goggles and aprons

Introduction to Shaper machine:

A **shaper** is a machine tool used to produce flat surfaces, grooves, and keyways. It works by **reciprocating a single-point cutting tool** across the workpiece. Material is removed during the **forward stroke**, while the **return stroke is idle**.

Shaper machines are simple, robust, and commonly used in workshops for low-volume production and repair jobs.

Major Parts of a Shaper

1. **Base:** Heavy structure supporting the entire machine.
2. **Column:** Vertical casting that houses the ram drive mechanism and supports the saddle and table.
3. **Ram:** A reciprocating part that holds the tool head. Moves forward and backward.
4. **Tool Head:** Holds the single-point cutting tool and allows adjustments such as tool angle and height.
5. **Work Table:** Supports the workpiece; can be moved vertically and horizontally.
6. **Cross Rail / Saddle:** Provides horizontal movement for the work table.
7. **Clapper Box:** Holds the tool post and allows the tool to lift slightly during return stroke to avoid rubbing.
8. **Feed Mechanism:** Gives automatic cross-feed after each stroke.

Working Principle

A shaper converts rotary motion into reciprocating motion of the ram. A single-point cutting tool is fitted on the ram. During the forward stroke, the tool cuts the material. During the return stroke, no cutting occurs. The quick return mechanism ensures that the return stroke happens faster, reducing machining time. The quick return mechanism increases productivity by making the cutting stroke slower and the return stroke faster.

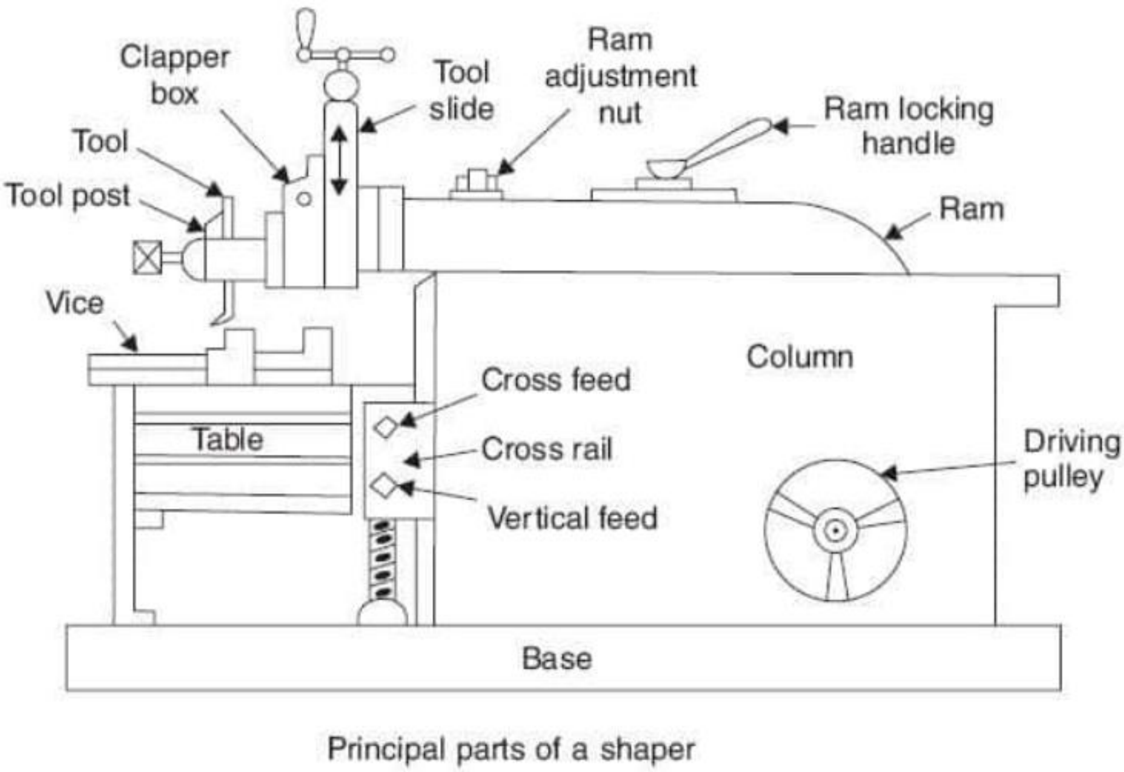


Figure 3.8: Components of shaper machine

Types of Quick Return Mechanisms

1. Crank and Slotted Link Mechanism
2. Whitworth Quick Return Mechanism

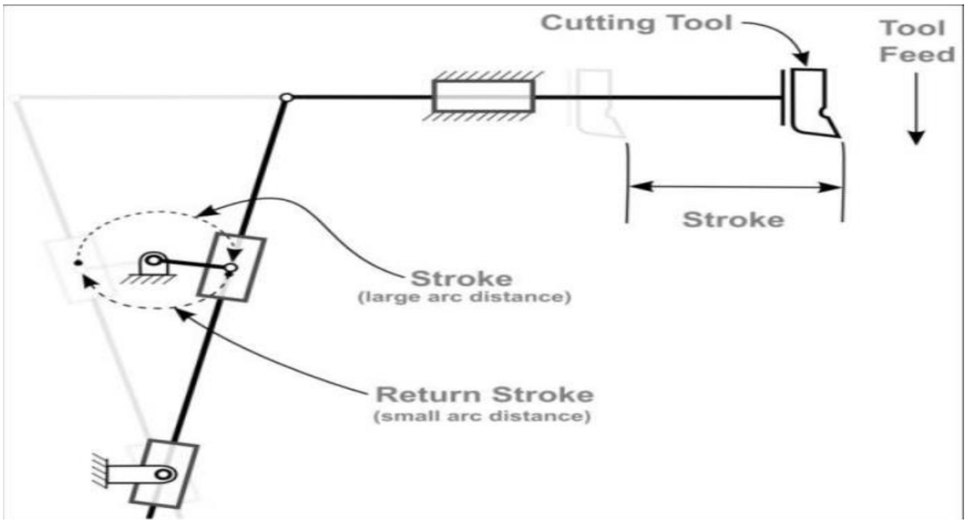


Figure: 3.9 Quick return mechanism

Working Concept

- A rotating disc or crank drives a slotted link or lever.
- This converts the rotary motion into reciprocating motion.

- Due to the geometry, the forward stroke covers a larger angle of rotation (slow) and the return stroke covers a smaller angle (fast).

Operations of Shaper

Shaper machines can perform the following operations:

1. Horizontal Cutting / Flat Surface Cutting: Producing flat surfaces on the top of a workpiece.

2. Vertical Cutting: Cutting vertical surfaces by adjusting the tool head.

3. Angular Cutting: Producing inclined surfaces by swiveling the tool head.

4. Slot Cutting: Making narrow slots or grooves on the workpiece.

5. Keyway Cutting: Machining keyways in shafts or hubs.

6. Contour Cutting: Producing irregular shapes within the capability of the machine.

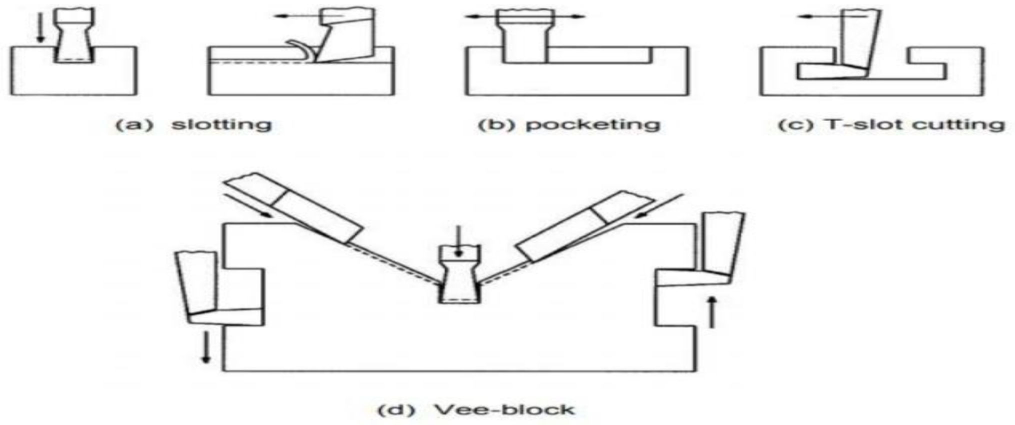


Fig 3.10: Different types of operations in shaper machine

Calculation of MRR

MRR= d.w.t/total machining time

d= length of job, w= width of job, t= depth of cut

<u>Assignment</u>

- Differentiate between shaper and planer machine
- Explain quick return mechanism with diagram
- How many degrees of freedom in shaper machine?
- What is the function of the ram and tool head?
- What is the purpose of the clapper box in a shaper?

Experiment 04: Study of Sand Casting Using Split Patterns and Analysis of Casting Defects.

Objectives

1. Understand the purpose and use of split patterns in mold making.
2. Identify different types of patterns used in casting.
3. Learn about various types of molding sands and their applications.
4. Understand the key properties required for good molding sand.
5. Learn about common casting defects and how they can be prevented.

Casting is a manufacturing method used to create metal parts by shaping molten metal in a mold. In sand casting, a pattern—often made of wood or metal—is used to form a cavity in sand, which determines the shape of the final part. The mold is held in a container called a flask, and additional features like cores and risers help shape internal cavities and prevent defects. This method is widely used because it can produce complex shapes in various sizes.

Different Types of Patterns

Single-Piece Pattern: The simplest pattern, made in one piece with the exact shape of the casting. It is placed in either the cope or drag and is used for small quantities of large castings.

Split Pattern: Divided into two or more parts along the parting plane to allow easy removal from the mold. Used for complex castings.

Match Plate Pattern: A split pattern fixed on both sides of a metal plate, with gates and runners attached. It reduces manual work and is suitable for mass production.

Cope and Drag Pattern: A split pattern with cope and drag mounted on separate plates. Used for large castings to make handling and molding easier.

Loose Piece Pattern: Used when projections prevent easy removal of a solid pattern from the mold. The projections are made as loose pieces, but they may shift during ramming.

Gated Pattern: Consists of one or more patterns with gates and runners already attached. It is mainly used for mass production of small castings.

Sweep Pattern: Made using a shaped wooden board rotated about a central point to form symmetrical mold cavities. Commonly used for large circular castings.

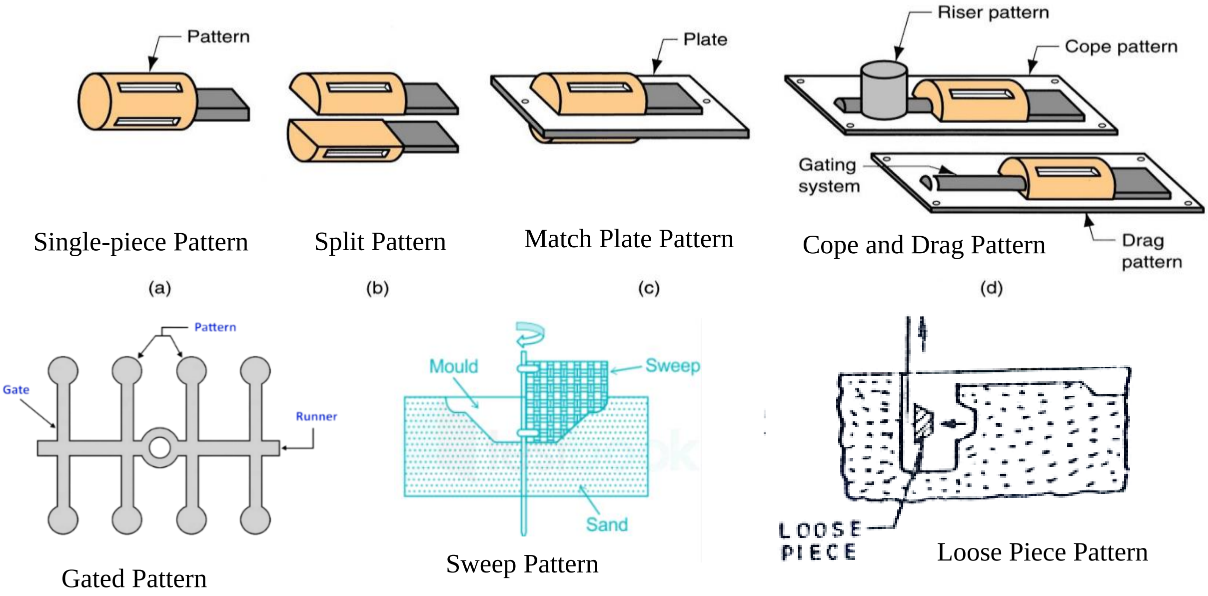


Figure 4.1: Different types of patterns

Molding Sands

Molding sands, or foundry sands, are evaluated based on eight key characteristics that determine their suitability for casting processes:

1. **Refractoriness** – Ability to withstand high molten metal temperatures without melting.
2. **Chemical Inertness** – Should not react with molten metal to avoid defects.
3. **Permeability** – Allows gases and steam to escape during pouring, preventing blow holes.
4. **Surface Finish** – Fine sand gives smoother cast surfaces but lowers permeability.
5. **Cohesiveness** – Ability to hold shape after pattern removal and resist mold collapse.
6. **Flowability** – Capability to flow and fill intricate mold details easily.
7. **Collapsibility** – Ability to break away after solidification to prevent cracks or hot tears.
8. **Availability and Cost** – Sand should be economical and readily available due to large usage.

Types of Molding Sand

1. **Green Sand** – Natural sand mixed with moisture and clay to provide mold strength.
2. **Dry Sand** – Green sand dried in an oven for higher strength; used for large castings.
3. **Facing Sand** – The sand that comes in direct contact with molten metal and forms the mold surface.
4. **Parting Sand** – Applied on parting surfaces to prevent sticking between cope, drag, and pattern.
5. **Backing Sand** – Supports the facing sand and fills the remaining portion of the flask.
6. **Core Sand** – High-silica sand mixed with binders to make strong and accurate cores.
7. **Loam Sand** – Sand with high clay content, dried hard and used for large loam molds.

Binders – Improve the bonding strength of sand (e.g., clay, oil, resin).
Additives – Enhance specific properties of sand without affecting bonding (e.g., wood flour, coal dust).

Steps in the production sequence of sand casting

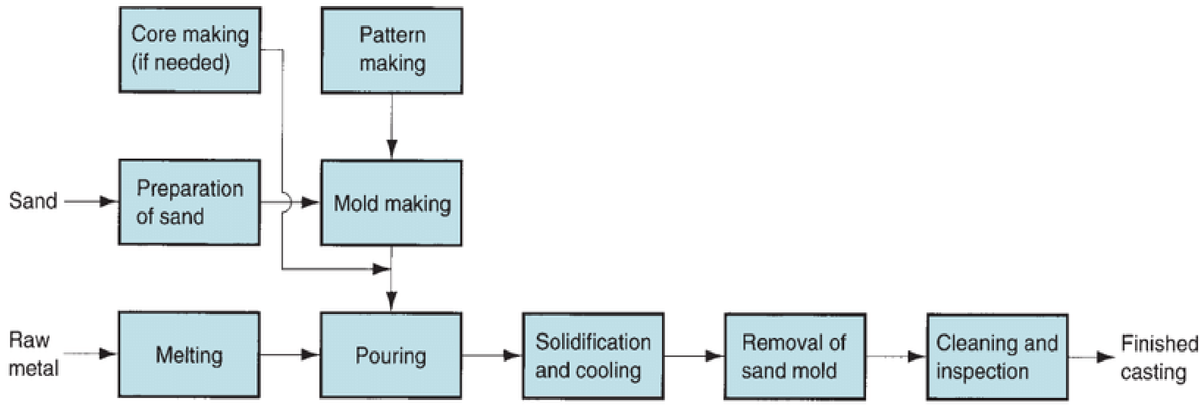


Figure 4.2: Steps in sand casting

Casting Defects

A casting defect is an undesired irregularity in a metal casting process. Some defects can be tolerated or repaired, while others, if not eliminated, may render the casting unusable.

Classification by Location

1. Surface Defects

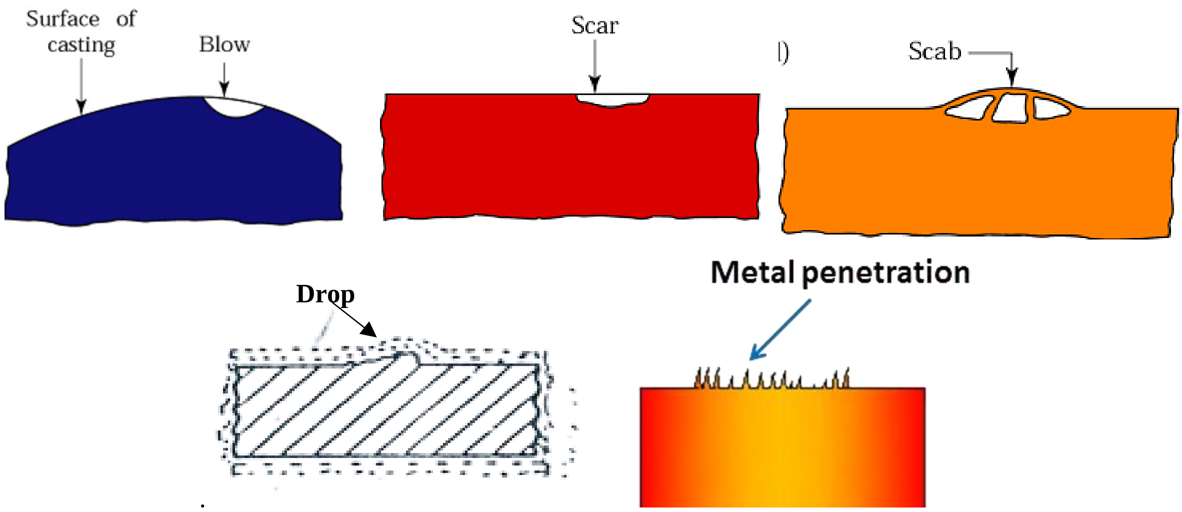


Figure 4.3: Different types of surface defects

2. Internal Defects

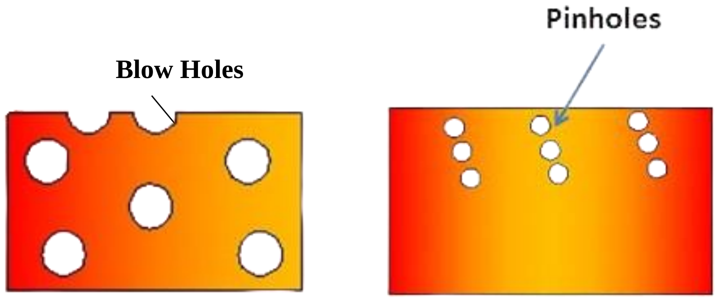
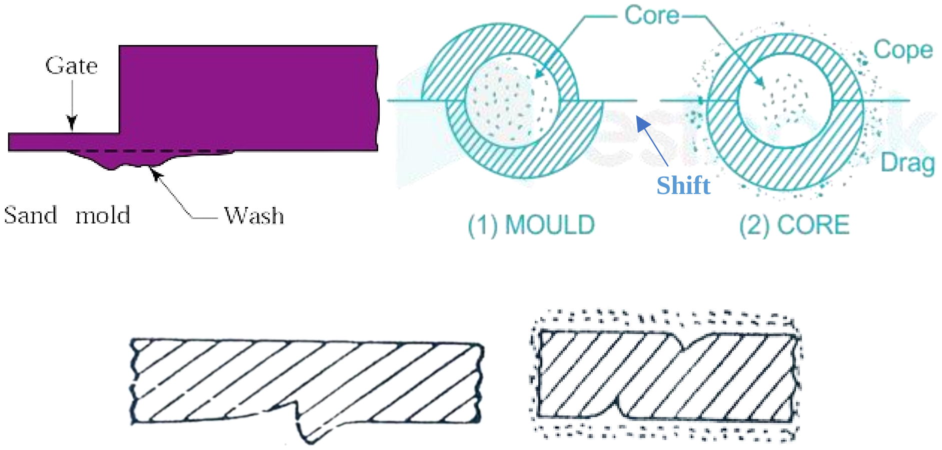


Figure 4.4: Different types of internal defects

3. Visible Defects



Rat Tail **Buckle**

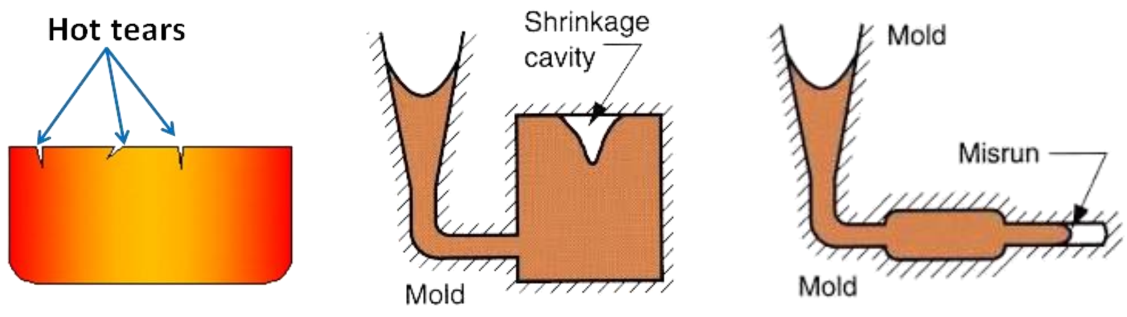


Figure 4.5: Different types of visible defects

Assignment:

a) Imagine you are designing a sand mold for a complex casting. Compare the use of a single-piece pattern, a split pattern, and a match-plate pattern. Which one would you choose for a mass-produced component and why?

b) Casting defects can ruin hours of work. Select three surface defects, two internal defects, and two visible defects. For each, describe what went wrong during molding or pouring, and suggest a way to prevent it. Use sketches.

c) Discuss how size, surface finish, and dimensional accuracy limit the use of castings. Provide examples of components where these limitations would be critical.

REPORT CONTENTS:

1. Objective
2. Equipment used
3. Figure (Digital image)
4. Working Procedure (Flow Chart)
5. Discussion
6. Question answer

Experiment 05: Study of Different Types of Joints by TIG Welding and MIG Welding

Objectives:

- Get familiar with TIG and MIG welding.
- To weld 3 pieces of dimensions 40mm×80mm, making butt and lap joints.
- Get acquainted with different types of welding defects.

Apparatus:

- Welding holders
- Electrodes
- Arc-welding machine
- Arc-welding station
- Gloves
- Welding screen
- Tong and
- Chipping Hammer

Background

Solid materials need to be joined together in order that they may be fabricated into useful shapes for various applications such as industrial, commercial, domestic, artware, and other uses. Depending on the material and the application, different joining processes are adopted, such as mechanical (bolts, rivets, etc.), chemical (adhesive), or thermal (welding, brazing, or soldering). Thermal processes are extensively used for joining of most common engineering materials, namely, metals.

Consumable electrode methods

Consumable electrode arc welding processes use an electrode that melts during welding, serving both to maintain the arc and to provide filler metal that deposits into the weld pool. This eliminates the need for a separate filler rod in most cases. The electrode material is chosen to be compatible with the base metal for proper fusion. These methods are widely used for their efficiency, higher deposition rates, and suitability for thicker materials or high-productivity applications. Common shielding methods include flux coatings (which produce protective slag and gas), external inert gases, or granular flux.

Some common consumable electrode arc welding processes:

- Shielded Metal Arc Welding (SMAW) / Stick welding
- Gas Metal Arc Welding (GMAW) / Metal Inert Gas (MIG) welding
- Flux-Cored Arc Welding (FCAW)
- Submerged Arc Welding (SAW)
- Electroslag Welding (ESW)
- Electro Gas Welding (EGW)

Non-consumable electrode methods

Non-consumable electrode arc welding processes use an electrode (typically made of high-melting-point materials like tungsten or carbon) that does not melt or get consumed during welding. The electrode primarily sustains the electric arc to generate heat, melting the base metal and (if needed) a separate filler material added manually or automatically. These methods often require external shielding gas to protect the weld pool and produce high-quality, precise welds with minimal contamination. They are ideal for thin materials, non-ferrous metals, and applications demanding clean, strong joints, though they generally require higher operator skill and are slower than consumable methods.

Some common non-consumable electrode arc welding processes:

- Gas Tungsten Arc Welding (GTAW) / Tungsten Inert Gas (TIG) welding
- Plasma Arc Welding (PAW)
- Carbon Arc Welding (CAW)
- Atomic Hydrogen Welding (AHW)

Welding Processes

Tungsten Inert Gas (TIG): Tungsten Inert Gas (TIG) or Gas tungsten arc welding (GTAW) is an arc welding process that uses a non-consumable tungsten electrode and an inert gas for arc shielding. Under the correct conditions, the electrode does not melt, although the work does at the point where the arc contacts and produces a weld pool. The TIG process can be implemented with or without a filler metal. Figure 1 illustrates the latter case. When a filler metal is used, it is added to the weld pool from a separate rod or wire, being melted by the heat of the arc rather than transferred across the arc as in the consumable electrode arc welding processes. Tungsten is a good electrode material due to its high melting point of 3410OC (61700F).

Since tungsten is sensitive to oxygen in the air, good shielding with oxygen-free gas is required. Typical shielding gases include argon, helium, or a mixture of these gas elements. TIG welding is easily performed on a variety of materials, from steel and its alloys to aluminum, magnesium, copper, brass, nickel, titanium, etc. Virtually any metal that is conductive lends itself to being welded using GTAW. Its clean, high-quality welds often require little or no post-weld finishing. This method produces the finest, strongest welds out of all the welding processes.

However, it's also one of the slower methods of arc welding.

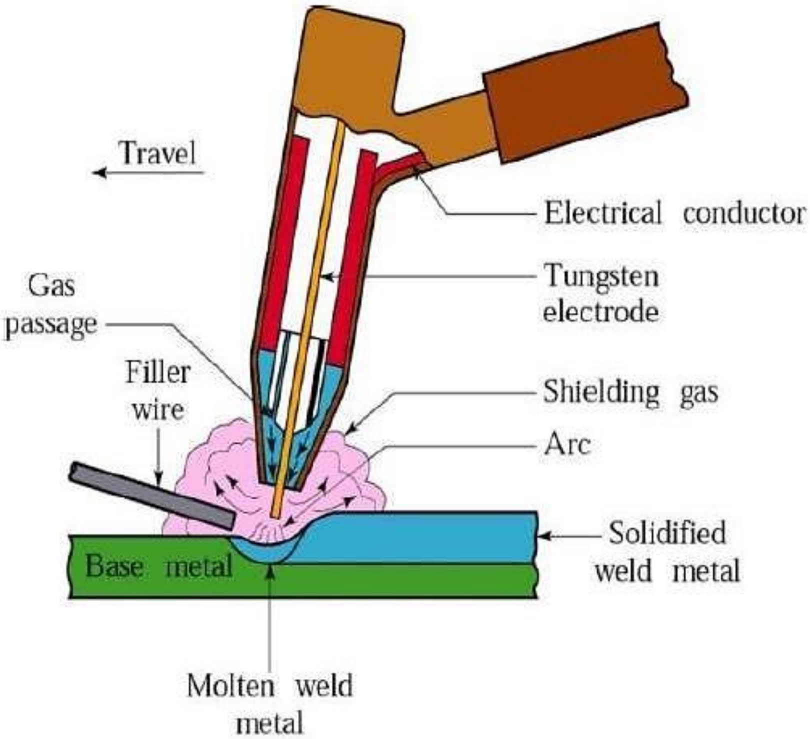


Fig 5.1: Tungsten Inert Gas (TIG)

Metal Inert Gas (MIG): MIG is an arc welding process that uses a consumable electrode consisting of a filler metal rod coated with chemicals that provide shielding. The process is illustrated in Figure 2. Under the correct conditions, the wire is fed at a constant rate to the arc, matching the rate at which the arc melts it. The filler metal is the thin wire that's fed automatically into the pool where it melts. The filler metal used in the rod must be compatible with the metal to be welded, the composition usually being very close to that of the base metal.

The coating on the rod consists of powdered cellulose mixed with oxides, carbonates, and other ingredients, held together by a silicate binder. Metal powders are also sometimes included in the coating to increase the amount of filler metal and to add alloying elements. The heat of the welding process melts the coating to provide a protective atmosphere and slag for the welding operation. It also helps to stabilize the arc and regulate the rate at which the electrode melts.

The molten metal is sensitive to oxygen in the air, good shielding with oxygen-free gases is required. This shielding gas (Argon, Helium, etc.) provides a stable, inert environment to protect the weld pool as it solidifies. Consequently, it is known as MIG (metal inert gas) welding. Since fluxes are not used, the welds produced are sound, free of contaminants, and as corrosion-resistant as the parent metal. Argon, helium, and carbon dioxide can be used alone or in various combinations for MIG welding of ferrous metals.

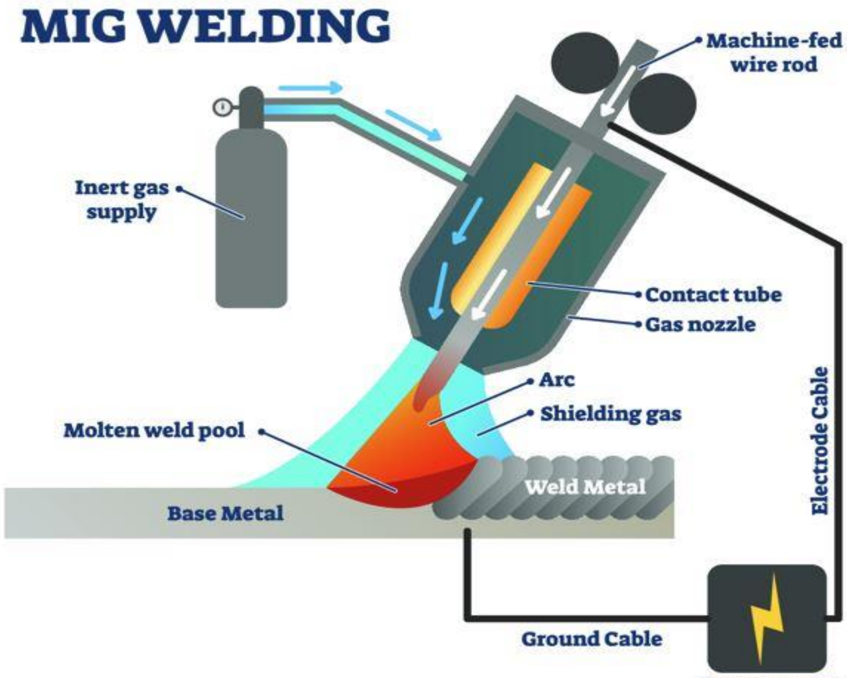


Fig 5.2: Metal Inert Gas (MIG)

Welding Joints:

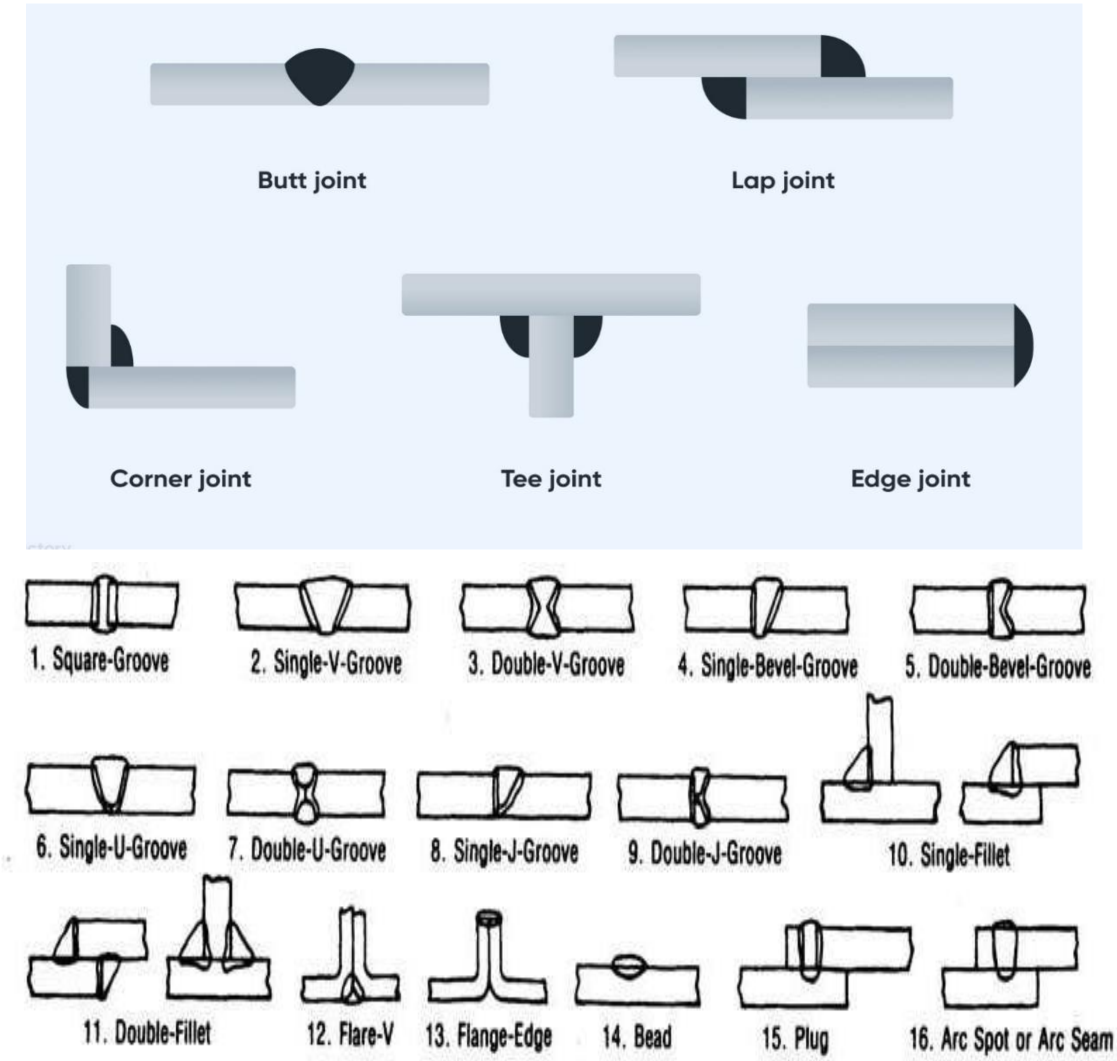


Fig 5.3: Basic Weld Joints

Common Welding Defects

Welding defects are imperfections that weaken the weld or reduce its quality. Here are some frequent ones with brief explanations:

Porosity: Small gas pockets trapped in the weld metal, appearing as holes; caused by contamination or improper shielding.

Undercut: Groove melted into the base metal along the weld toe, reducing thickness; due to high current or poor technique.

Incomplete Penetration: Weld metal fails to fully penetrate the joint thickness, caused by low heat or improper joint preparation.

Lack of Fusion: No bonding between weld metal and base metal or between passes; from insufficient heat or contamination.

Cracks: Fractures in the weld or heat-affected zone; often from rapid cooling, stress, or hydrogen embrittlement.

Spatter: Small metal droplets expelled and stuck around the weld; caused by high current or unstable arc.

Inclusion: Foreign material (slag, oxide) trapped in the weld, due to poor cleaning or flux issues.

Burn-Through: Excessive melting creating a hole in the base metal; from too high heat input on thin materials.

Overlap: Weld metal flows over the base without fusing due to slow travel speed or low heat.

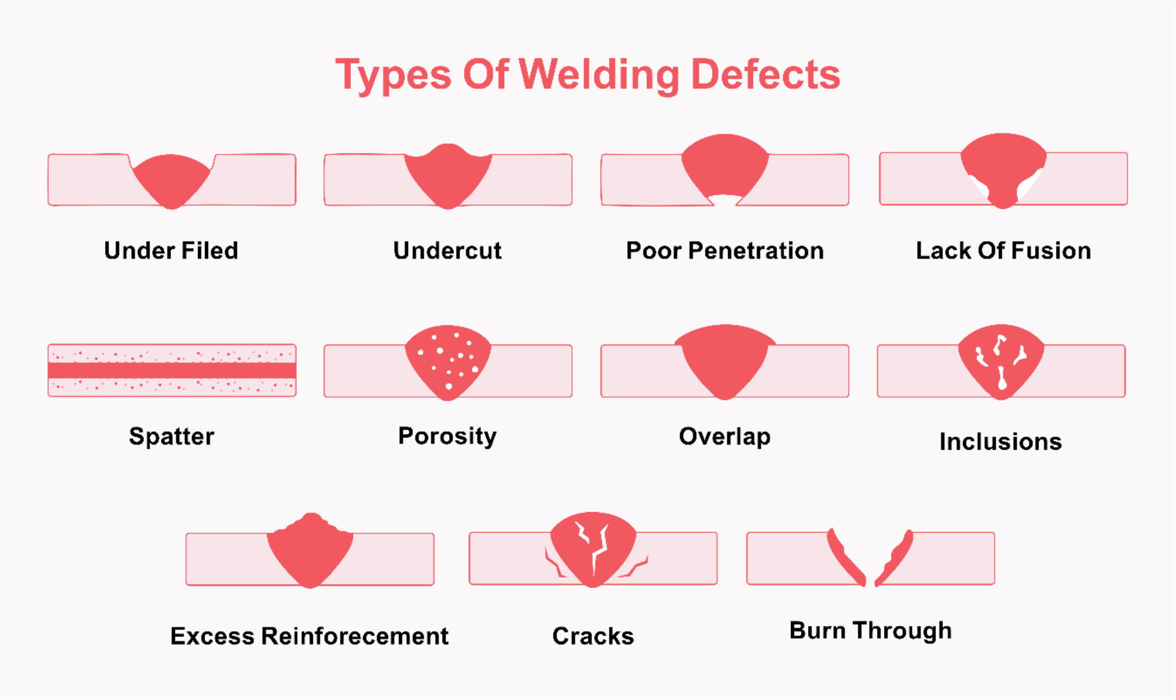


Fig 5.4: Common Welding Defects

Assignment:

- Differentiate between TIG and MIG Welding
- What shielding gases are used in TIG welding, and why?
- How do you identify porosity vs. inclusions?