Ahsanullah University of Science and Technology

Department of Electrical and Electronic Engineering

LABORATORY MANUAL

FOR

ELECTRICAL AND ELECTRONIC SESSIONAL COURSE

Student Name :

Student ID :

EEE - 1102 ELECTRICAL CIRCUITS – I LAB

Department of EEE 1^{st} Year, 1^{st} Semester

EEE - 1132 BASIC ELECTRICAL TECHNOLOGY LAB.

Department of CE 1^{st} Year, 1^{st} Semester

EEE - 1242 BASIC ELECTRICAL ENGINEERING LAB.

Department of CSE 1^{st} Year, 2^{nd} Semester

EEE - 1288 BASIC ELECTRICAL ENGINEERING LAB.

Department of ME and MPE 1^{st} Year, 2^{nd} Semester

EEE - 2262 ELEMENTS of ELECTRICAL ENGINEERING and ELECTRONICS LAB

Department of TE 2^{nd} Year, 2^{nd} Semester

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
2^{nd} Year, 1^{st} Semester

Student Name :
Student ID :

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

IPE 2102: Manufacturing process sessional
Credit Hour: 1.5

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-1

Study of Sand Casting and Casting Defects

Objectives:

- To understand the fundamental principles and basic operations of industrially used casting processes
- To be conversant with commonly used terminology in casting process
- To learn about common casting defects
- To recognize the importance of safety in a foundry and execute proper safety measures in carrying out casting processes.

Introduction:

This foundry workshop sessional aims to provide students good appreciation of commonly used industrial casting technologies. The applications, limitations, advantages and common industrial practices in obtaining integrity metal casting will be addressed throughout this sessional class.

This experiment will provide students with both theatrical and practical knowledge of foundry and casting by short lectures and hand-on practices. Students can benefit the most by active interactions with our staff members and self-exploration while ding the casting exercises.

Apparatus:

- Flask
- Master pattern
- Round nose trowel
- Rammer
- Slicker spoon
- Lifter/Cleaner
- Spatula

Process Description:

Sand casting is one of the traditional casting methods fabricating metal parts. The sand cast part is produced by forming a mold from a sand mixture and pouring molten liquid metal into the cavity in the mold. A pattern with a shape very similar to the desired casting, is first placed in sand to make an imprint. A gating system is incorporated and the resultant cavity is filled with molten metal. After the melts cool and solidify, casting can then be obtained by breaking the sand mold. Since the molding material of sand casting is sand, rough surface and lack of dimensional accuracy are the intended result and therefore post machining is usually needed. Typical application of sand casting are machine tool bases, engine blocks and cylinder heads.

There are six steps in the process:

- Place a pattern in sand to create a mold.
- Incorporate gating system

- Remove the pattern
- Fill the mold cavity with molten metal
- Allow the metal to cool
- Break away the sand mold and remove the casting.

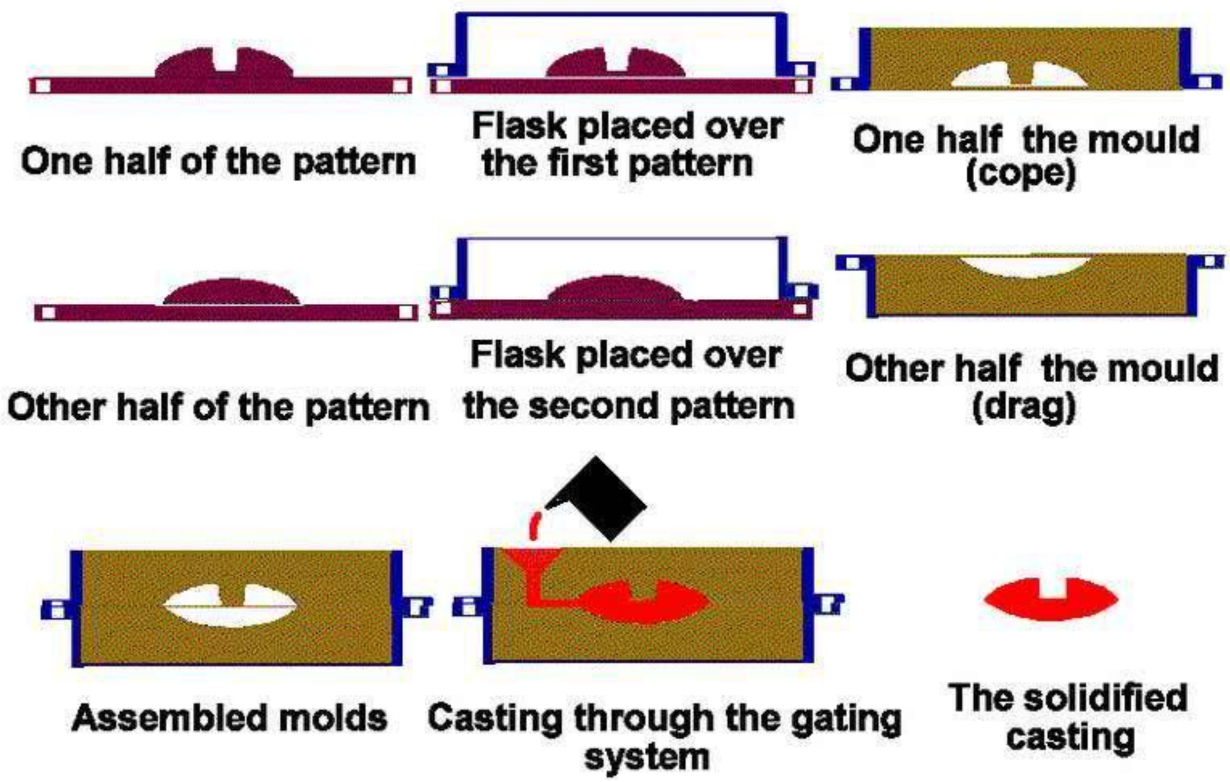


Figure 1.1: A METAL CASTING POURED IN SAND MOLD

Casting defects:

Common casting defects are:

- Blow holes
- Gas porosity
- Shrinkage porosity
- Hot tear
- Misrun
- Cold shut
- Etc

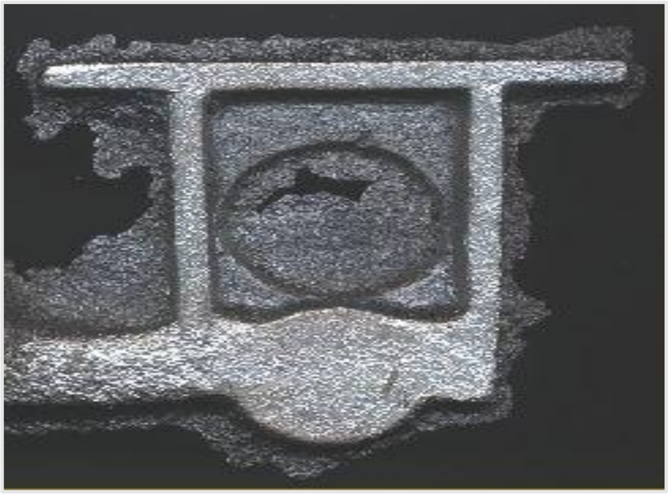


Figure 1.2

Figure 1.3

Figure 1.4

Figure 1.5

Figure 1.6

Figure 1.7

1. **Blow holes:** Small holes visible on the surface of the casting are called open blows whereas occurring below the surface of the casting.
   Causes: High moisture in sand resulting in low permeability, very hard ramming of sand and improper venting of mold.

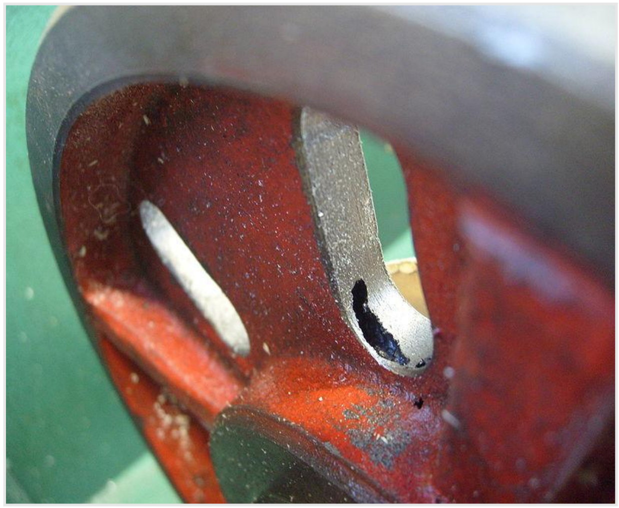


Figure 1.8: Blow Hole

2. **Misrun:**It is a casting that is incomplete in its outermost sections, because either it is too large or because the metal was poured with insufficient superheat.

   Causes: Too cold molten metal, too thin casting section, too small gates

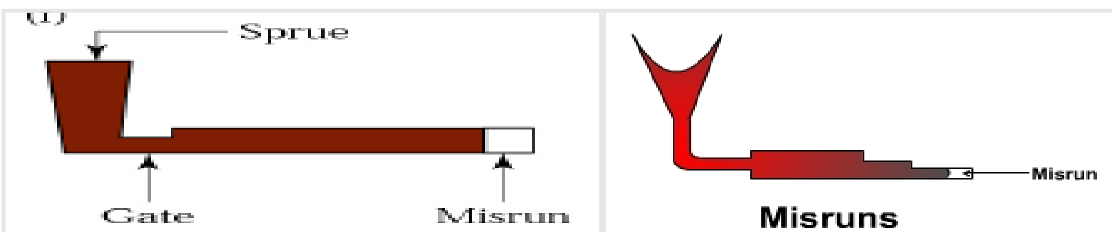


Figure 1.9: Misrun

3. **Cold shut:** It is an interface within a casting that lacks complete fusion and is formed when two streams of liquid from two different directions come together after the leading surfaces are solidified
   Causes: Metal lacking in fluidity, too small gates, too cold molten metal.

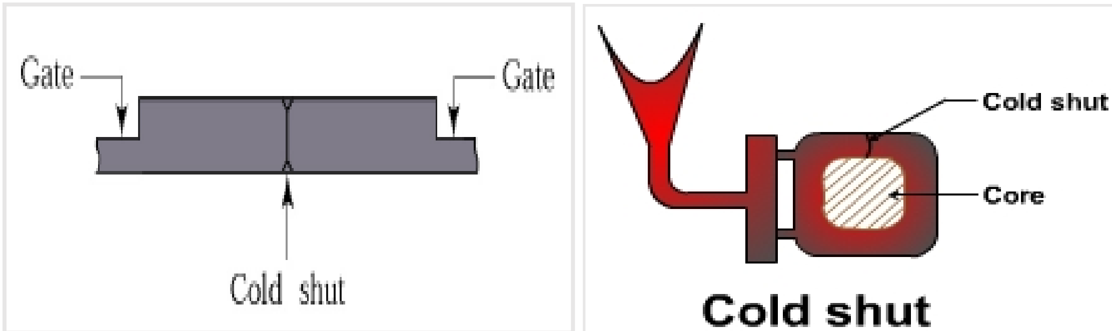


Figure 1.10: Cold Shut

4. **Shrinkage porosity:**This is a porosity due to shrinkage. May be caused to any kind of castings.
Causes: Non-uniformity of metal cooling and insufficient metal pouring may result in shrinkage porosity. So enough material should be poured through the riser.

Figure 1.11

5. **Hot tear:** Inter-granular (along grain boundaries) failure at a high temperature the larger sections for intensive strain induced by solid contraction of adjacent thinner section**.**
Causes: Excessive mold hardness, high drag and hot strength of sand mold, too much shrinkage of metal while solidifying, too low pouring temperature

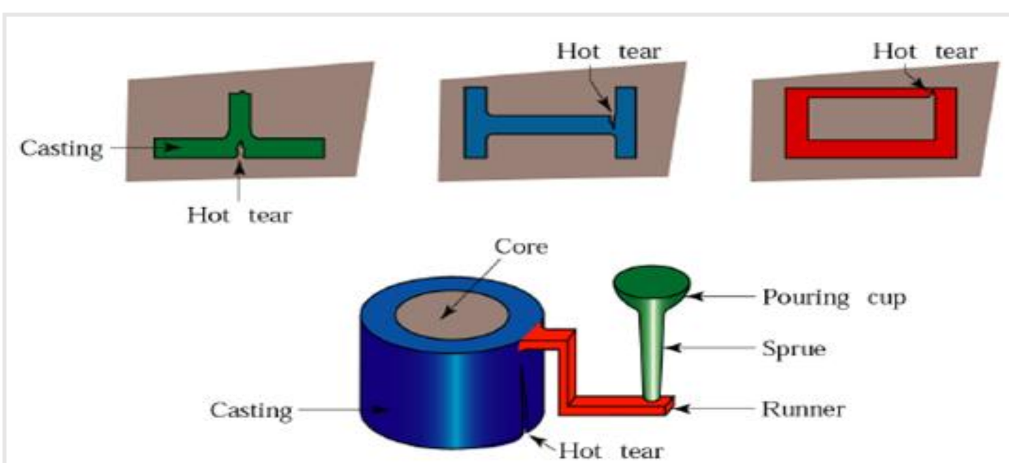


Figure 1.12

6. **Gas porosity:** Formation of bubbles within the casting after it has cooled.Solubility in liquid is high but in solid it is low. So, gas is rejected during cooling.
Causes: Using faulty or poor quality metal, use excessive moist sand

Figure 1.13

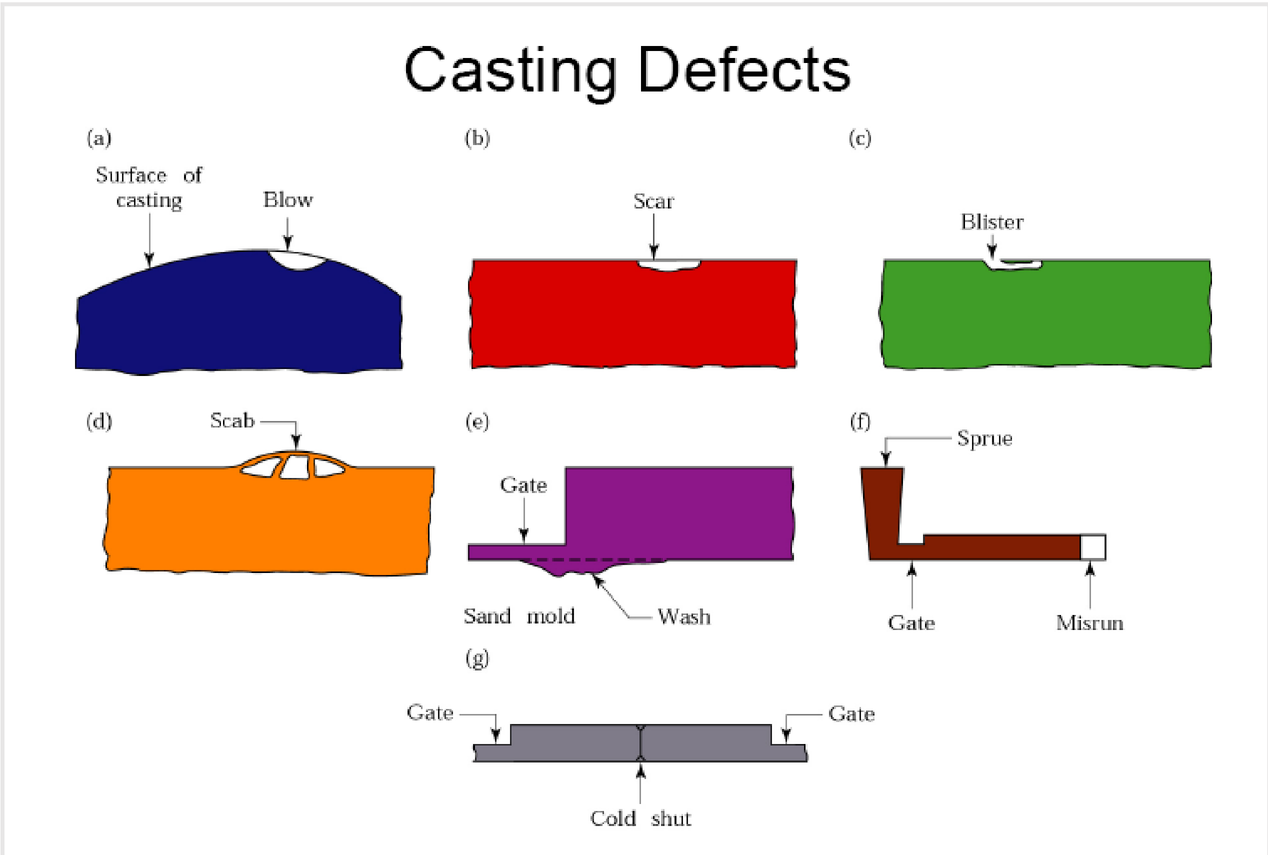


Figure 1.14

Assignments:

- Define Pattern. List different types of patterns in foundry.
- Describe the different types of pattern allowances. Can any of the allowances be negative? If yes, then explain why?
- What are the usual defects in green sand casting? What may be their remedies?

Experiment-2

Study of Different types of Joints and Defects by Arc-Welding TIG MIG Welding

Arc Welding:

Objective:

- Get familiar with arc and TIG 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

Process (Arc Welding) Detail:

Arc welding is a process where two or more metals are joined by the immense heat generated by the arc produced between the filler metal and the work piece (s).Filter metal is the material that is added to the weld pool to assist in filling the gap (or groove). Filler metal forms an integral part of the weld.Filler rods have the same or nearly the same chemical composition as the base metal.

During welding, if the metal is heated/melted in air, oxygen from the air combines with the metal to form oxides which result in poor quality, low strength welds or, in some cases, may even make welding impossible. A flux is a material used to prevent, dissolve or facilitate removal of oxides and other undesirable substances. A flux prevents the oxidation of molten metal. The flux (material) is fusible and non-metallic.During welding, flux chemically reacts with the oxides and a slag is formed that floats to and covers the top of the molten puddle of metal and thus helps keep out atmospheric oxygen and other gases.

Figure 2.1: Filler rod

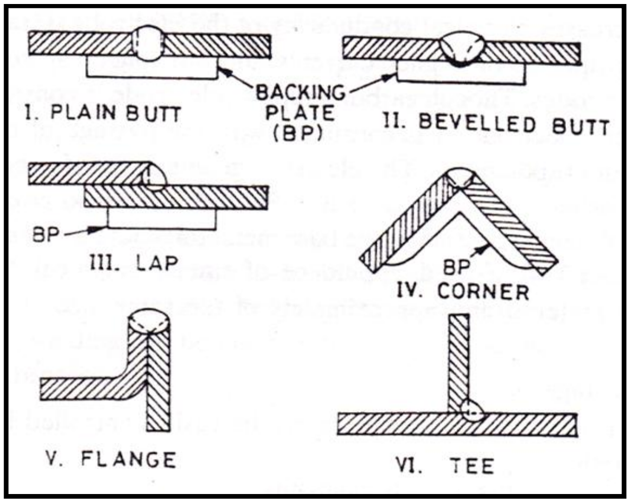


Figure 2.2: Joints produced by arc welding

Procedures:

- Keep two pieces side by side and make a small weld on the edges of the two sides. See that the pieces are uniformly joint.
- Make a clean welding by moving the electrode (held in the holder slowly along the joint on both sides).
- Now hold the pieces with a long and chip off the flux with a chipping hammer.
- Now place the third piece on the other work pieces such that half of the piece lies on it.
- Now proceed as earlier.

Precautions:

- Wear an apron.
- Wear a full sleeves cotton shirt so that sparks don't harm.
- Wear shoes with a rubber sole.
- Use a shield to protect eyes from spark.
- Handle the equipment carefully.

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 tungstenelectrode 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 34100C (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.

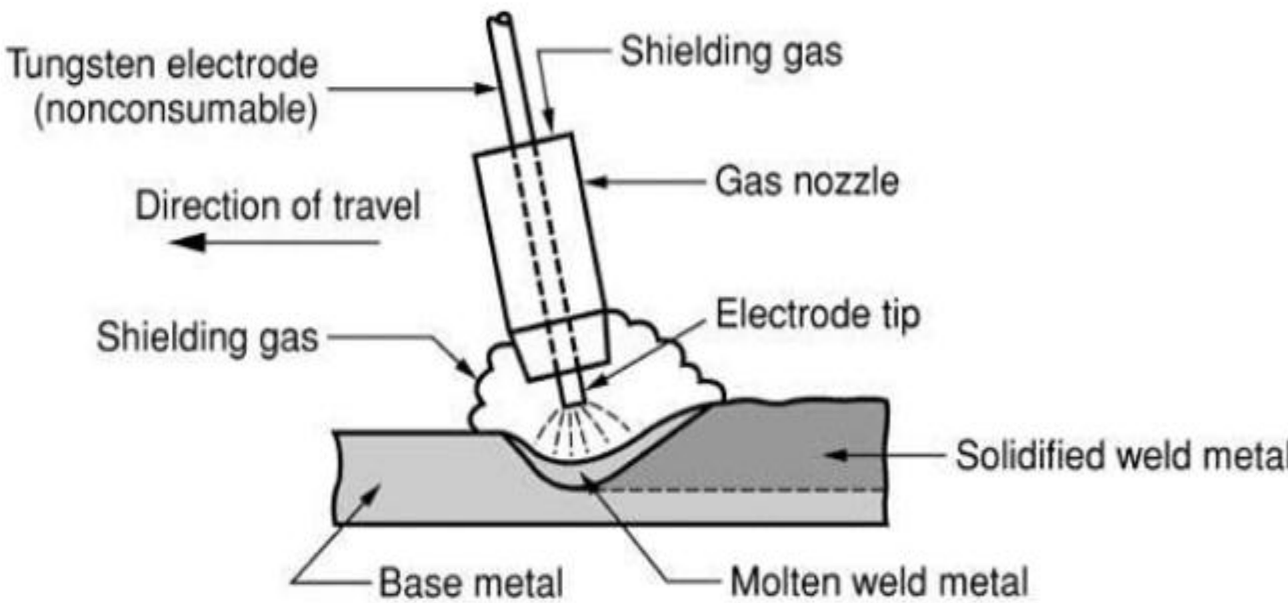


Figure 1: Tungsten Inert Gas (TIG)

Figure 2.3

Metal Inert Gas (MIG): Metal Inert Gas (MIG) is an arc welding process that uses a consumable electrode consistingof a filler metal rod coated with chemicals that provide shielding.The process is illustratedin Figure2. 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.

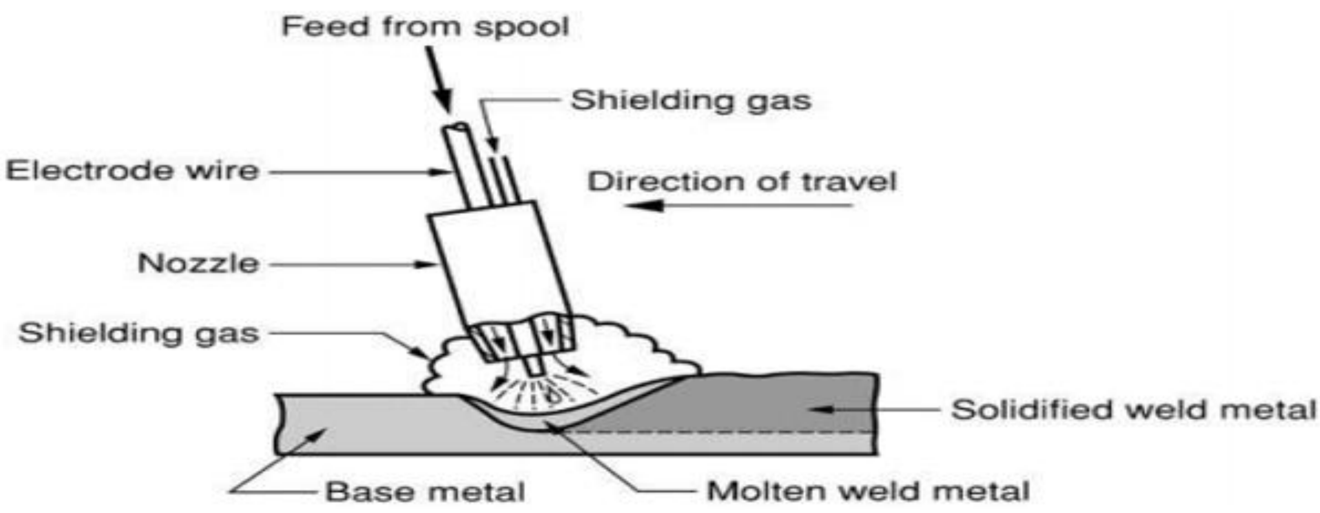


Figure 2: Metal Inert Gas (MIG)

Figure 2.4

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

Welding Joints:

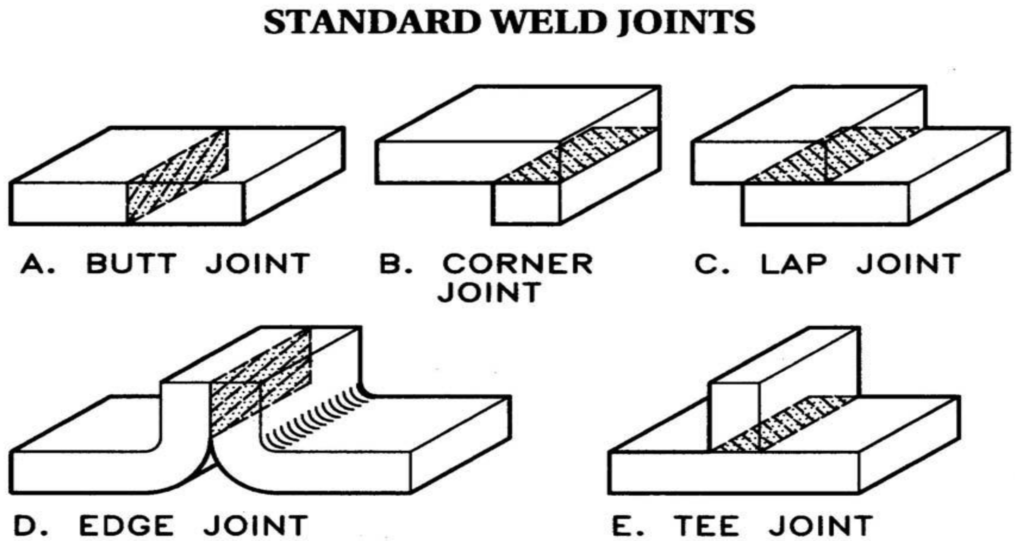


Figure 2.5:Standard Weld Joints

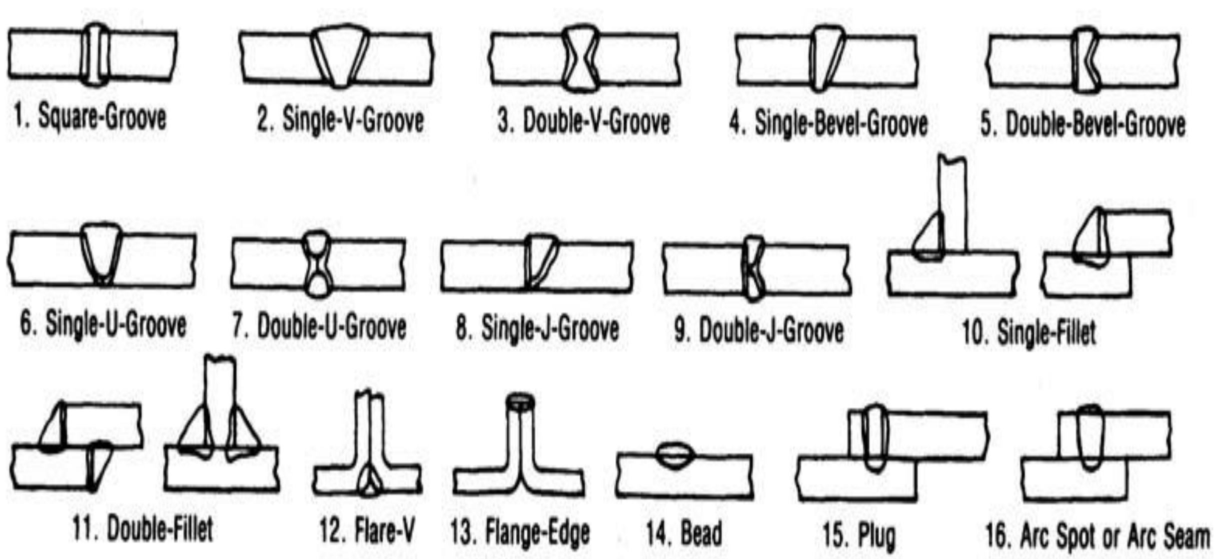


Figure 2.6: Other basic Weld Joints

Common Welding Defects:

Arc strike cracking

Arc strike cracking occurs when the arc is struck but the spot is not welded. This occurs because the spot is heated above the material's upper critical temperature and then essentially quenched. This forms martensite, which is brittle and may lead to higher chances of micro-cracks. Usually the arc is struck in the weld groove so this type of crack does not occur, but if the arc is struck outside of the weld groove then it must be welded over to prevent the cracking. If this is not an option then the arc spot can be post heated, that is, the area is heated with an oxy-acetylene torch, and then allowed to cool slowly.

Cold cracking

Residual stresses can reduce the strength of the base material, and can lead to catastrophic failure through cold cracking. Cold cracking is limited to steels and is associated with the formation of martensite as the weld cools. The cracking occurs in the heat-affected zone of the base material. To reduce the amount of distortion and residual stresses, the amount of heat input should be limited, and the welding sequence used should not be from one end directly to the other, but rather in segments.[7]

Cold cracking only occurs when all the following preconditions are met:

- susceptible microstructure (e.g. martensite)
- hydrogen present in the microstructure (hydrogen embrittlement)
- service temperature environment (normal atmospheric pressure): -100 to +100 °F
- high restraint

Eliminating any one of these will eliminate this condition.

Crater crack

Crater cracks occur when a crater is not filled before the arc is broken. This causes the outer edges of the crater to cool more quickly than the crater, which creates sufficient stresses to form a crack. Longitudinal, transverse and/or multiple radial cracks may form.

Hat crack

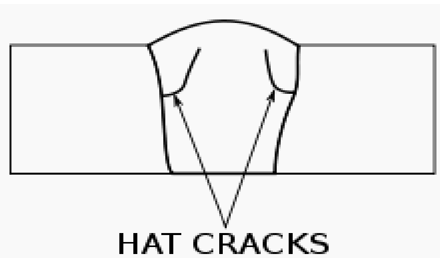


Figure 2.7

Hat cracks get their name from the shape of the cross-section of the weld, because the weld flares out at the face of the weld. The crack starts at the fusion line and extends up through the weld. They are usually caused by too much voltage or not enough speed.

Hot cracking

Hot cracking, also known as solidification cracking, can occur with all metals, and happens in the fusion zone of a weld. To diminish the probability of this type of cracking, excess material restraint should be avoided, and a proper filler material should be utilized.Other causes include too high welding current, poor joint design that does not diffuse heat, impurities (such as sulfur and phosphorus), preheating, speed is too fast, and long arcs.

Underbead crack

An undercut crack, also known as a heat-affected zone (HAZ) crack, is a crack that forms a short distance away from the fusion line; it occurs in low alloy and high alloy steel. The exact causes of this type of crack are not completely understood, but it is known that dissolved hydrogen must be present. The other factor that affects this type of crack is internal stresses resulting from: unequal contraction between the base metal and the weld metal, restraint of the base metal, stresses from the formation of martensite, and stresses from the precipitation of hydrogen out of the metal.

Longitudinal crack

Longitudinal cracks run along the length of a weld bead. There are three types: check cracks, root cracks, and full centerline cracks. Check cracks are visible from the surface and extend partially into the weld. They are usually caused by high shrinkage stresses, especially on final passes, or by a hot cracking mechanism. Root cracks start at the root and extent part way into the weld. They are the most common type of longitudinal crack because of the small size of the first weld bead. If this type of crack is not addressed then it will usually propagate into subsequent weld passes, which is how full cracks (a crack from the root to the surface) usually form.[8]

Reheat cracking

Reheat cracking is a type of cracking that occurs in HSLA steels, particularly chromium, molybdenum and vanadium steels, during postheating. The phenomenon has also been observed in austenitic stainless steels. It is caused by the poor creep ductility of the heat affected zone. Any existing defects or notches aggravate crack formation. Things that help prevent reheat cracking include heat treating first with a low temperature soak and then with a rapid heating to high temperatures, grinding or peening the weld toes, and using a two layer welding technique to refine the HAZ grain structure.

Root and toe cracks

A root crack is the crack formed by the short bead at the root(of edge preparation) beginning of the welding, low current at the beginning and due to improper filler material used for welding. Major reason for happening of these types of cracks is hydrogen embrittlement. These types of defects can be eliminated using high current at the starting and proper filler material. Toe crack occurs due to moisture content present in the welded area, it as a part of the surface crack so can be easily detected. Preheating and proper joint formation is must for eliminating these types of defects.

Transverse crack

Transverse cracks are perpendicular to the direction of the weld. These are generally the result of longitudinal shrinkage stresses acting on weld metal of low ductility. Crater cracks occur in the crater when the welding arc is terminated prematurely. Crater cracks are normally shallow, hot cracks usually forming single or star cracks. These cracks usually start at a crater pipe and extend longitudinal in the crater. However, they may propagate into longitudinal weld cracks in the rest of the weld.

Distortion

Welding methods that involve the melting of metal at the site of the joint necessarily are prone to shrinkage as the heated metal cools. Shrinkage then introduces residual stresses and distortion. Distortion can pose a major problem, since the final product is not the desired shape. To alleviate certain types of distortion the workpieces can be offset so that after welding the product is the correct shape. The following pictures describe various types of welding distortion:[15]

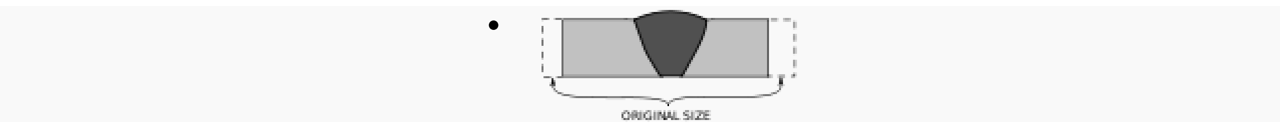


Figure 2.8: Transverse shrinkage

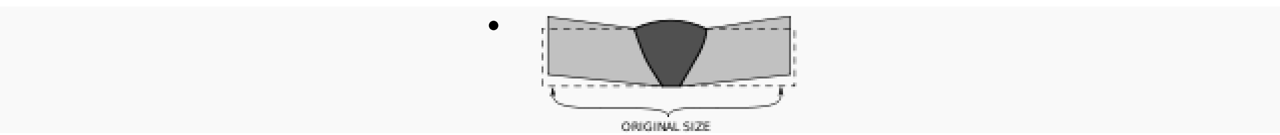


Figure 2.9: Angular distortion

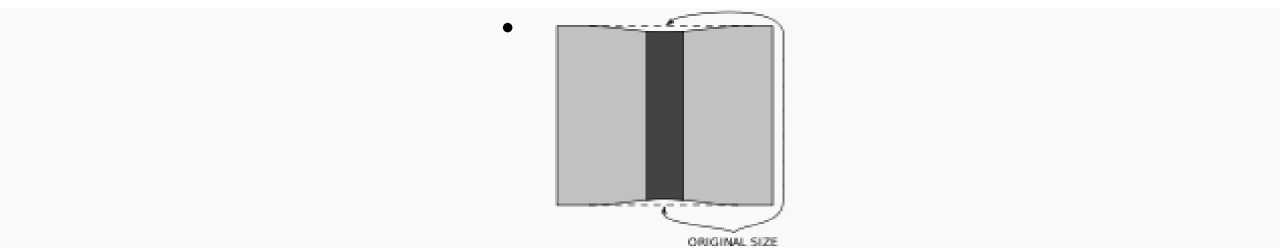


Figure 2.10: Longitudinal shrinkage

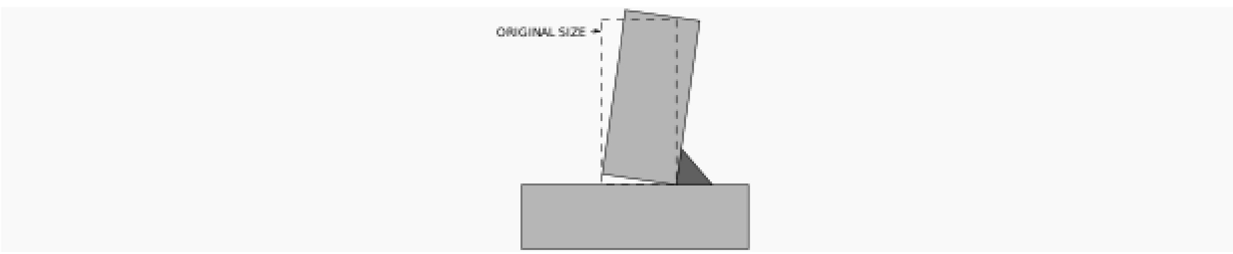


Figure 2.11: Fillet distortion

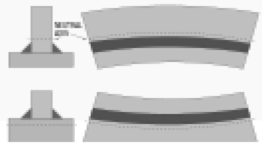


Figure 2.12: Neutral axis distortion

Gas inclusion

Gas inclusions is a wide variety of defects that includes porosity, blow holes, and pipes (or wormholes). The underlying cause for gas inclusions is the entrapment of gas within the solidified weld. Gas formation can be from any of the following causes: high sulphar content in the workpiece or electrode, excessive moisture from the electrode or workpiece, too short of an arc, or wrong welding current or polarity.

Inclusions

There are two types of inclusions: linear inclusions and rounded inclusions. Inclusions can be either isolated or cumulative. Linear inclusions occur when there is slag or flux in the weld. Slag forms from the use of a flux, which is why this type of defect usually occurs in welding processes that use flux, such as shielded metal arc welding, flux-cored arc welding, and submerged arc welding, but it can also occur in gas metal arc welding. This defect usually occurs in welds that require multiple passes and there is poor overlap between the welds. The poor overlap does not allow the slag from the previous weld to melt out and rise to the top of the new weld bead. It can also occur if the previous weld left an undercut or an uneven surface profile. To prevent slag inclusions the slag should be cleaned from the weld bead between passes via grinding, wire brushing, or chipping.

Isolated inclusions occur when rust or mill scale is present on the base metal.

Lack of fusion and incomplete penetration

Lack of fusion is the poor adhesion of the weld bead to the base metal; incomplete penetration is a weld bead that does not start at the root of the weld groove. Incomplete penetration forms channels and crevices in the root of the weld which can cause serious issues in pipes because corrosive substances can settle in these areas. These types of defects occur when the welding procedures are not adhered to; possible causes include the current setting, arc length, electrode angle, and electrode manipulation. Defects can be varied and classified as critical or non critical. Porosity (bubbles) in the weld are usually acceptable to a certain degree. Slag inclusions, undercut, and cracks are usually unacceptable. Some porosity, cracks, and slag inclusions are visible and may not need further inspection to require their removal. Small defects such as these can be verified by Liquid Penetrant Testing (Dye check). Slag inclusions and cracks just below the surface can be discovered by Magnetic Particle Inspection. Deeper defects can be detected using the Radiographic (X-rays) and/or Ultrasound (sound waves) testing techniques.

Undercut

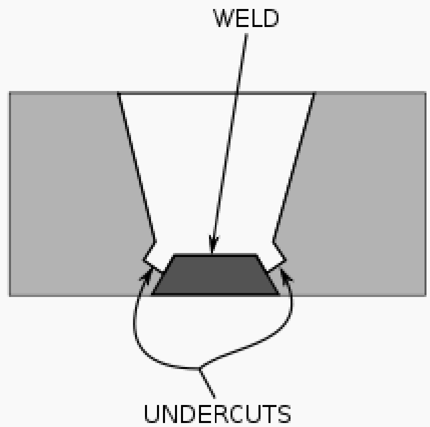


Figure 2.13

Undercutting occurs when the weld reduces the cross-sectional thickness of the base metal and which reduces the strength of the weld and workpieces. One reason for this type of defect is excessive current, causing the edges of the joint to melt and drain into the weld; this leaves a drain-like impression along the length of the weld. Another reason is if a poor technique is used that does not deposit enough filler metal along the edges of the weld. A third reason is using an incorrect filler metal, because it will create greater temperature gradients between the center of the weld and the edges. Other causes include too small of an electrode angle, a dampened electrode, excessive arc length, and slow speed.

Assignments:

- What are the criteria for good welding?
- How penetration of welding joint can be varied?
- Discuss the problems faced in arc welding.
- Why shielded electrodes are used?
- What do you understand by straight and reverse polarity?
- Differentiate between traverse crack and hat crack.
- What can be remedies of gas inclusion and distortion?

Experiment-3

Different Types if Turning Operations in Lathe Machine

Objectives:

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

Introduction:

Turning is the process whereby a center lathe is used to produce "solids of revolution". It can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using a computer controlled and automated lathe which does not. This type of machine tool is referred to as having computer numerical control, better known as CNC and is commonly used with many other types of machine tool besides the lathe.

When turning, a piece of material (wood, metal, plastic even stone) is rotated and a cutting tool is traversed along 2 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 until the advent of CNC it had become unusual to use one for this purpose for the last three quarters of the twentieth century. It is said that the lathe is the only machine tool that can reproduce itself.

Different types of turning operations:

1. Straight turning
2. Taper turning
3. Facing
4. Grooving
5. Boring
6. Threading
7. Knurling
8. Drilling
9. Countersinking
10. Counterboring
11. Etc.

Straight Turning:

In straight turning the feed of the tool is parallel to the axis of rotation of the job resulting in a straight cylindrical shape.

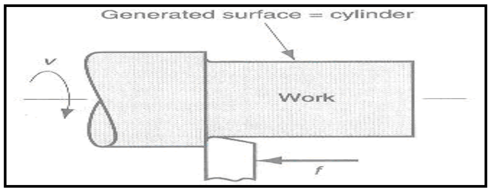


Figure 3.1: Straight Turning

Taper Turning:

Instead of feed the tool parallel to the axis of rotation of the work, the tool is fed at an angle, thus creating a taper cylinder or conical shape.

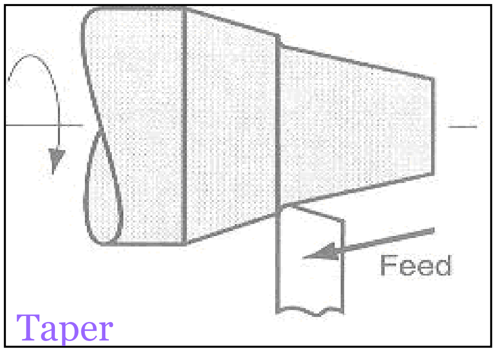


Figure 3.2: Taper Turning

Facing:

The tool is fed radially into the rotating work on one end to create a flat surface on the end.

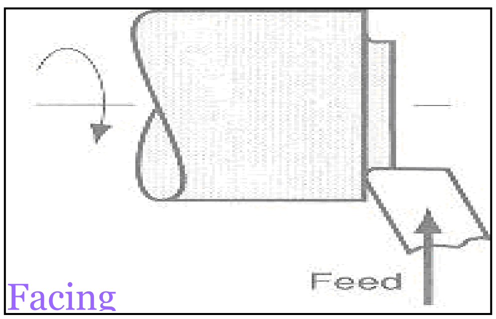


Figure 3.3: Facing

Grooving:

In this the shape of the cutting tool is imparted on the job. So it is also called form turning or forming.

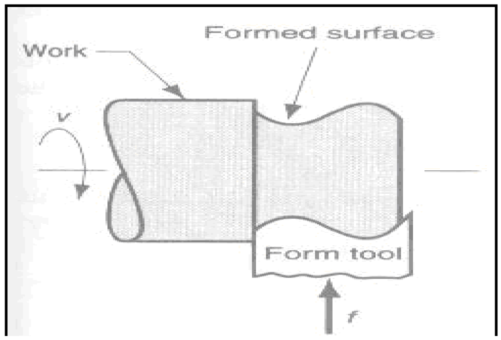


Figure 3.4: Grooving

Boring:

A single point is fed linearly parallel to the axis of rotation, on the inside diameter of an existing hole in the part.

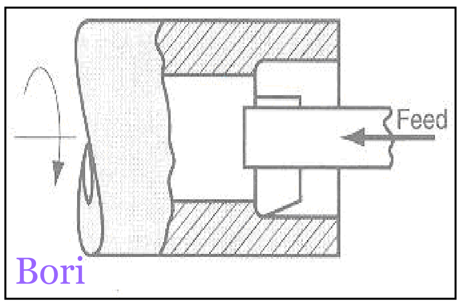


Figure 3.5: Taper Turning

Threading: A pointed tool is fed linearly across the outside surface of the rotating work part in a direction parallel to the axis of rotation at a large effective feed rate, thus creating threads in the cylinder.

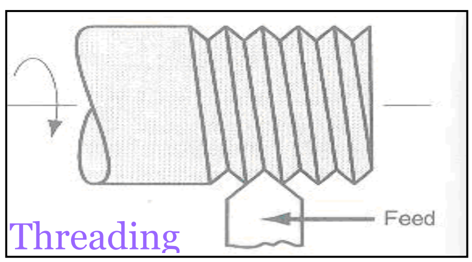


Figure 3.6: Threading

Drilling: Drilling can be performed on a lathe by feeding the drill into the rotating work along its axis. Reaming can be performed in a similar way.

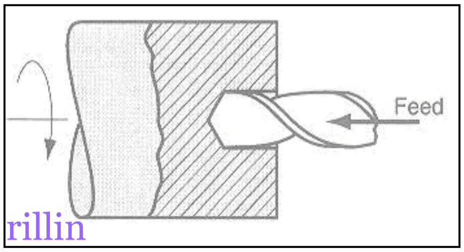


Figure 3.7: Drilling

Counterboring:

Counterboring is the process of producing a cylindrical flat-bottomed hole that enlarges another coaxial hole. 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 work piece's surface.

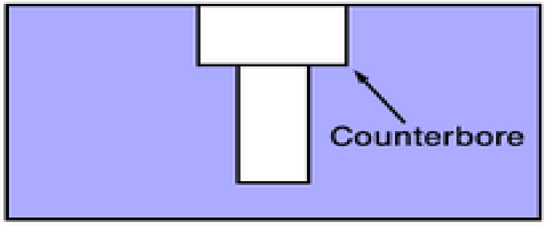


Figure 3.8: Counterboring

Counterbores are made with standard dimensions for a certain size of screw or are produced in sizes that are not related to any particular screw size. In either case, the tip of the counterbore has a reduced diameter section referred to as the pilot, a feature essential to assuring concentricity between the counterbore and the hole being counterbored. Counterboring can be done by lathe, milling or drilling machines.

Figure 3.9: Counterboring tools

Countersinking:

A countersink is a conical hole cut into a manufactured object, or the cutter used to cut such a hole. A common use is to allow the head of a countersunk bolt or screw, when placed in the hole, to sit flush with or below the surface of the surrounding material (by comparison, a counterbore makes a flat-bottomed hole that might be used with a socket-head cap screw). A countersink may also be used to remove the burr left from a drilling or tapping operation thereby improving the finish of the product and removing any hazardous sharp edges.

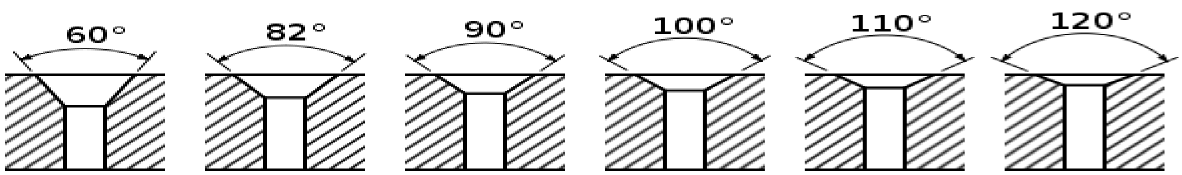


Figure 3.10: Cross-section of countersunk holes of chamfer angles

Countersinking tools can ne fluted or non-fluted. The fluted countersink cutter is used to provide a heavy chamfer in the entrance to a drilled hole. This may be required to allow the correct seating for a countersunk-head screw or to provide the lead in for a second machining operation such as tapping. Countersink cutters are manufactured with six common angles, which are 60°, 82°, 90°, 100°, 110°, or 120°.

Figure 3.11: Countersinking cutters (4-fluted and non-fluted)

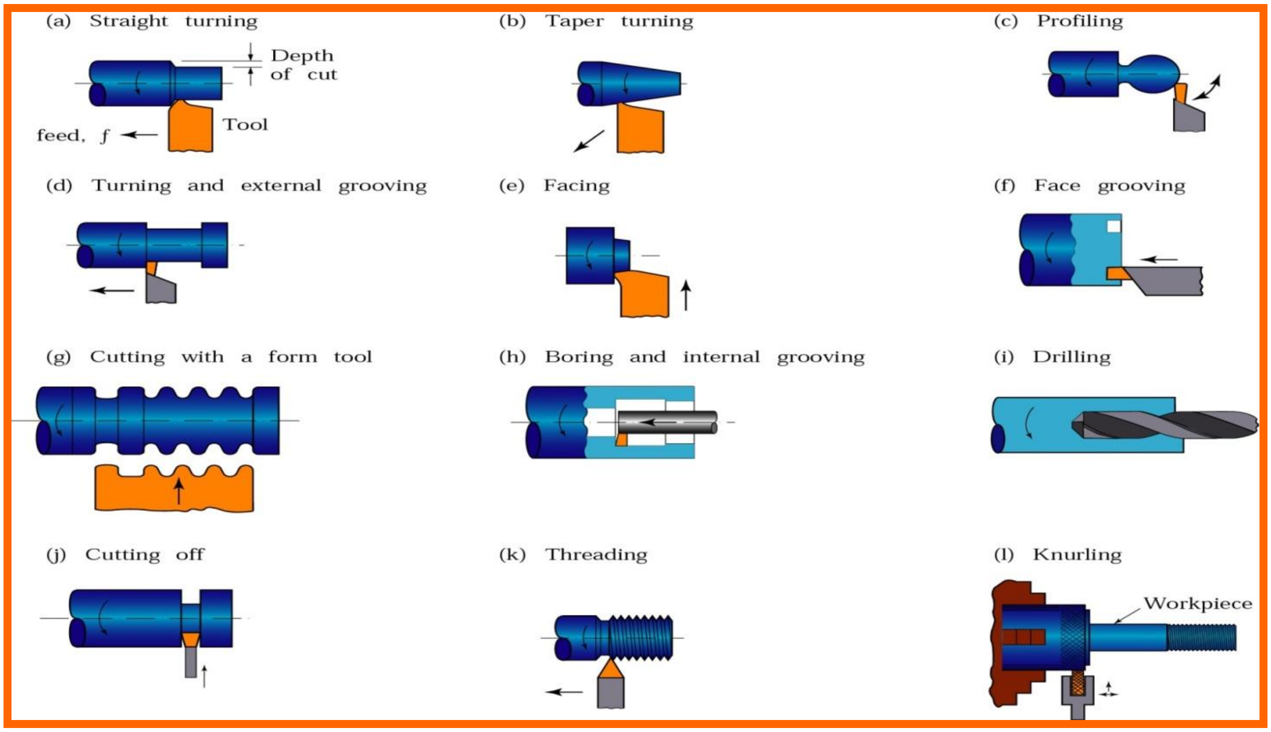


Figure 3.12: Different types of turning operations

Precautions:

- Never turn on the lathe machine when the tool and work piece is in contact.
- Wear shoes and apron to protect skin from heated chips.

Assignments:

- Differentiate between countersinking and counter-boring operation.
- Explain the function of cutting fluid in lathe work.
- Explain why high RPM does not mean high cutting speed?
- What are the four ways of taper turning in a lathe machine?

Experiment-4

Study of Different Types of Milling Operations in Order to Make a Part

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

Types of milling machine:

There are two major types of milling machine, the vertical milling machine and the horizontal milling machine. As their names imply, a vertical milling machine spindle is vertical and the horizontal milling machine spindle is horizontal (Figure: 4.1). In addition the vertical milling machine has a machine table that moves perpendicular to the spindle axis of rotation and the horizontal milling machine has a work table that moves parallel to the spindle axis of rotation(Figure: 4.2).

The vertical milling machine is the most common type found in the machine shop today. However during the first half of 20^{th} century the horizontal milling machine was the primary machine tool used for milling purposes. There are far fewer horizontal milling machines in production today than vertical machines. Another type of mill is the combination milling machine (Figure: 4.3). This is a hybrid of the vertical and horizontal. Still another type of specialty milling machine is the universal milling machine (Figure: 4.4). It is usually a horizontal milling machine with a swiveling plate. This type of milling machine will be shown in the machine tool sessional lab.

Figure: 4.1

Figure: 4.2

Figure: 4.3

Figure: 4.4

Parts of Horizontal Milling Machine:

- **Column:** The column houses the spindle, the bearings, the gearbox, the clutches, the shafts, the pumps, and the shifting mechanisms for transmitting power from the electric motor to the spindle at a selected speed.
- **Knee:** The knee mounted in front of the column is for supporting the table and to provide an up or down motion along the Z axis.

- **Saddle:** The saddle consists of two slide ways, one on the top and one at the bottom located at 90º to each other, for providing motions in the X or Y axes by means of lead screws
- **Table:** The table is mounted on top of the saddle and can be moved along the X axis. On top of the table are some T-slots for the mounting of work piece or clamping fixtures.
- **Arbor:** The arbor is an extension of the spindle for mounting cutters. Usually, the thread end of an arbor is of left hand helix.

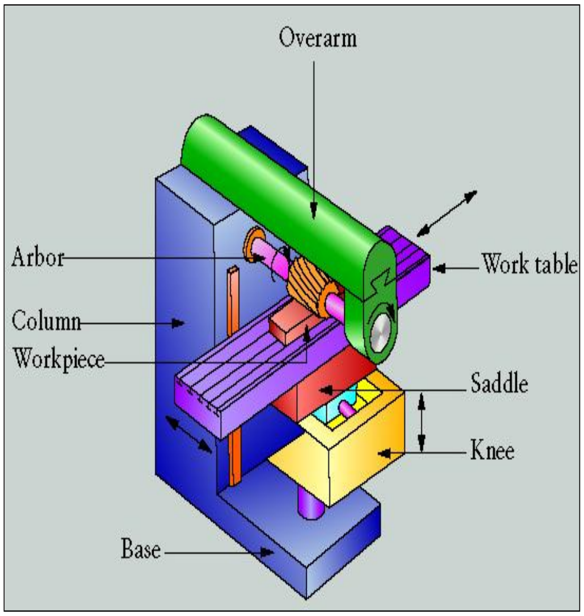


Figure 4.5: Horizontal Milling Machine

Parts of Vertical Milling Machine:

- **Column:** The column houses the spindle, the bearings, the gearbox, the clutches, the shafts, the pumps, and the shifting mechanisms for transmitting power from the electric motor to the spindle at a selected speed.
- **Knee:** The knee mounted in front of the column is for supporting the table and to provide an up or down motion along the Z axis**.**
- **Saddle:** The saddle consists of two slide ways, one on the top and one at the bottom located at 90º to each other, for providing motions in the X or Y axes by means of lead screws.
- **Table:** The table is mounted on top of the saddle and can be moved along the X axis. On top of the table are some T-slots for the mounting of work piece or clamping fixtures.
- **Milling head:** The milling head consisting the spindle, the motor, and the feed control unit is mounted on a swivel base such that it can be set at any angle to the table.

- **Ram**: The ram on which the milling head is attached can be positioned forward and

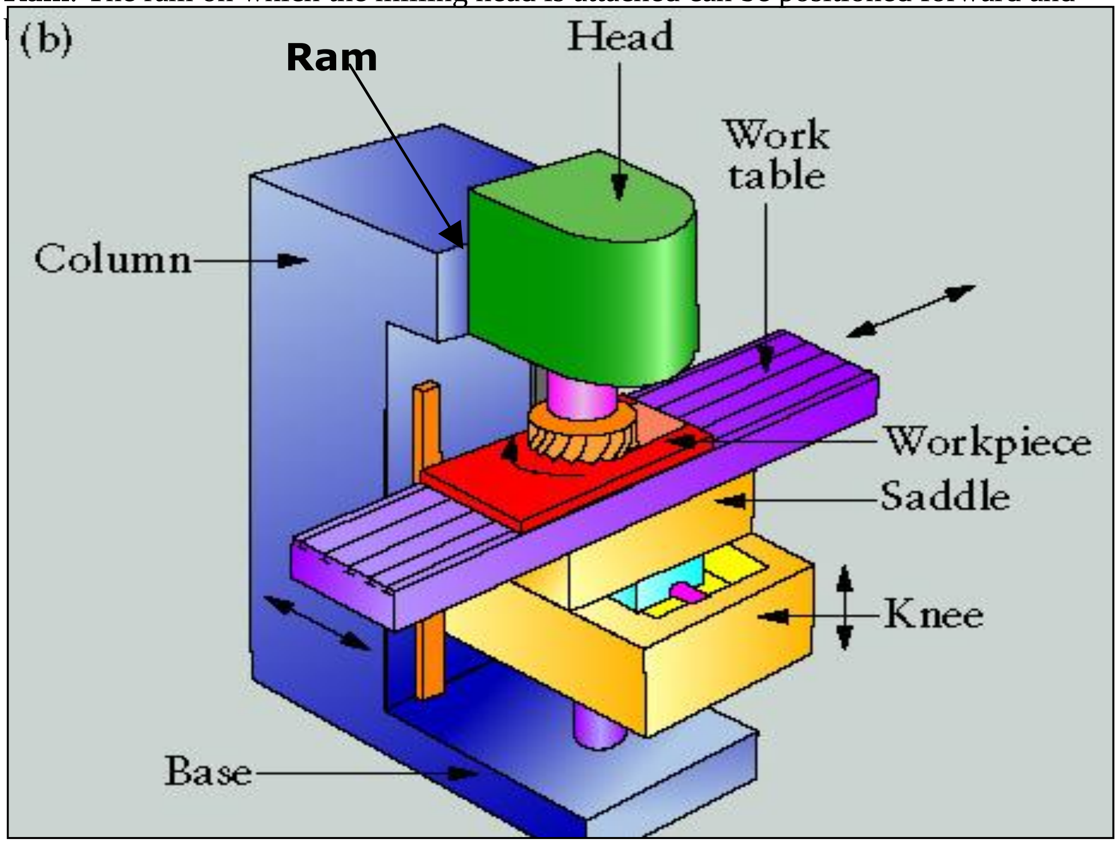


Figure 4.6: Vertical Milling Machine

Milling Methods:

1.Up Milling:

In up cut milling, the cutter rotates in a direction opposite to the table feed as illustrated in the following Figure. It is conventionally used in most milling operations because the backlash between the lead screw and the nut of the machine table can be eliminated.

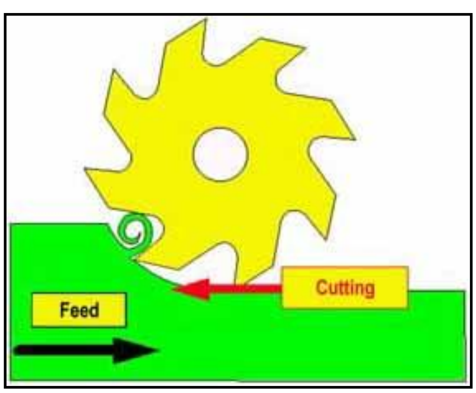


Figure 4.7: Up milling

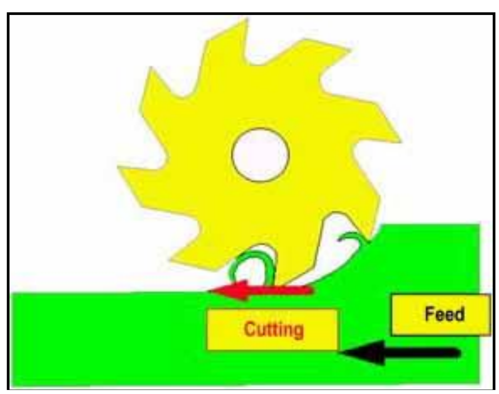


Figure 4.8: Down milling

2. Down Milling:

In down cut milling, the cutter rotates in the same direction as the table feed as illustrated in the following Figure. This method is also known as Climb Milling and can only be used on machines equipped with a backlash eliminator or on a CNC milling machine. This method, when properly treated, will require less power in feeding the table and give a better surface finish on the work piece.

Classification 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 work piece 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 work piece 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.

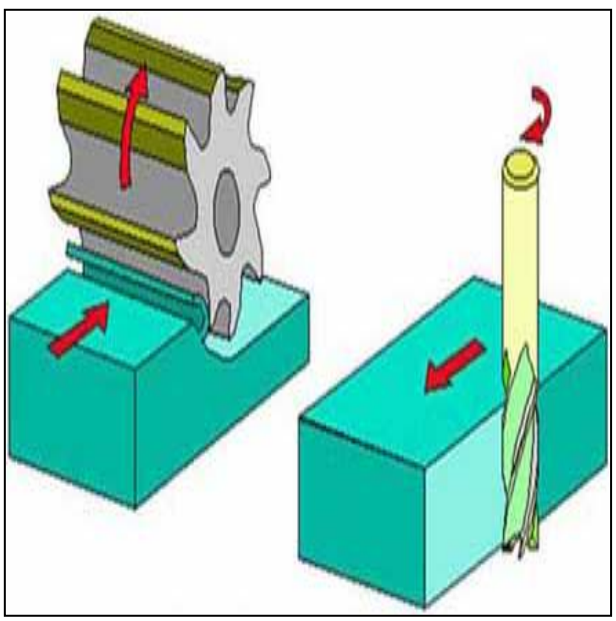


Fig 4.9:Peripheral Milling

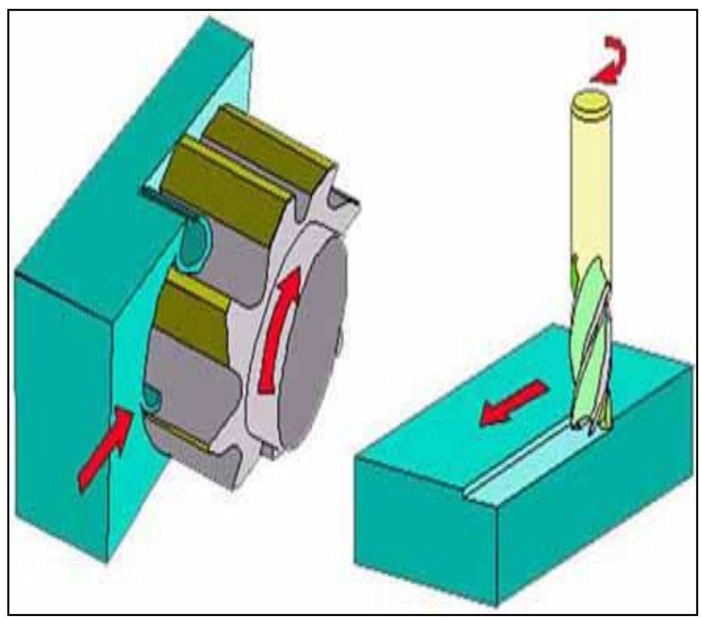
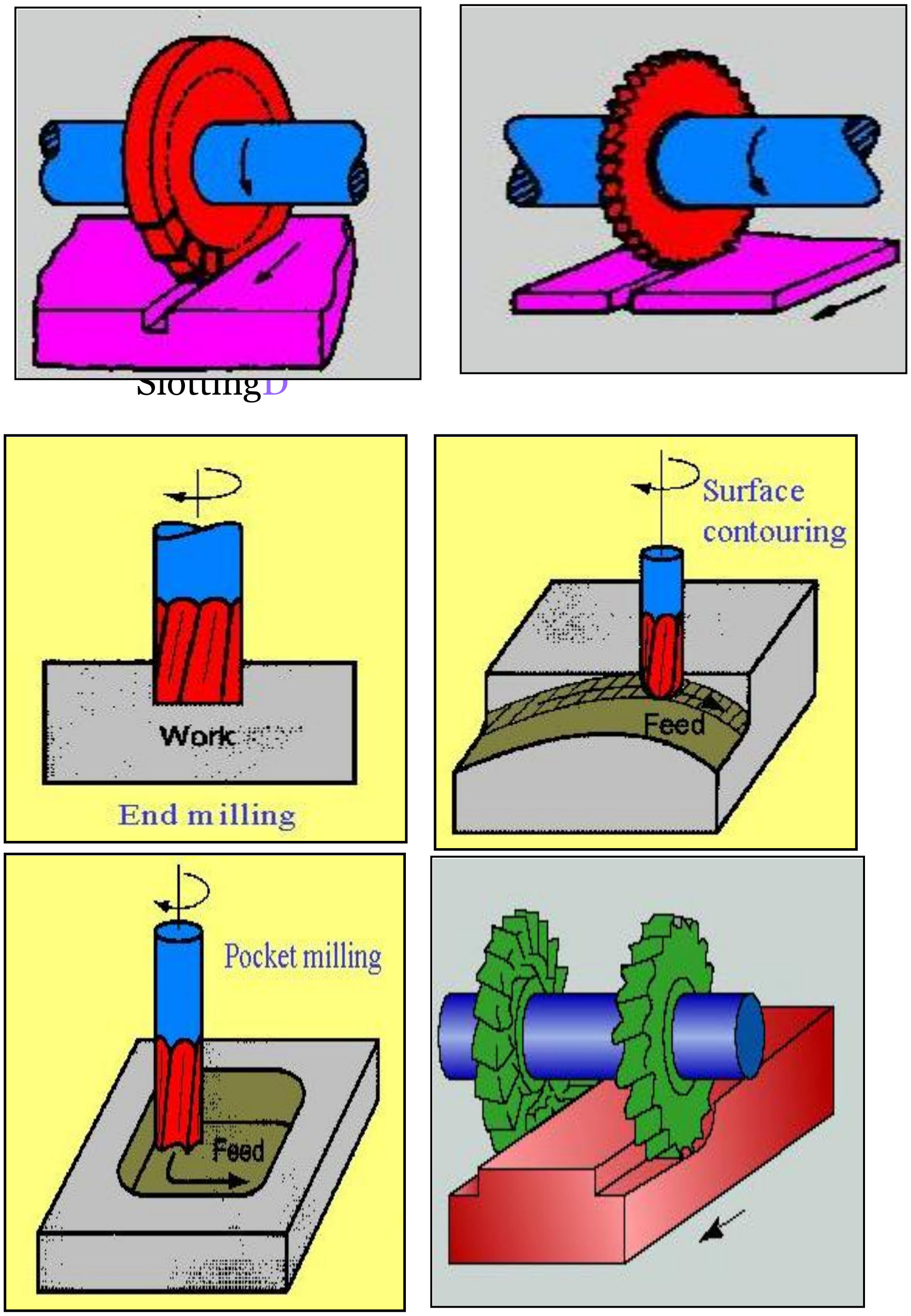


Fig 4.10: Face Milling



StraddleSlitting

Figure 4.11: Different types of milling operations

Formulae Necessary for Calculations:

$$\text{Spindle Speed}, N = \frac{1000\,V}{\Pi\,D}$$

Where

N = R.P.M. of the cutter
V = Linear cutting speed of the material in m/min. (as shown in Table-1)
D = Diameter of cutter in mm

Table feed rate, f= ft. N. n

Materialremoval rate, MRR= w. d. f

Where,

f = Table fee

d 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

Table-1: Cutting speed and Feed rate for some common material			
Tool Material	**High Speed Steel**		**Carbide**
Material	**Cutting speed (v)**	**Feed (f)**	**Cutting speed (v)**
Mild Steel	**25**	**0.08**	**100**
Aluminium	**100**	**0.15**	**500**
Hardened Steel	**---**	**---**	**50**

Assignments:

- Explain the differences between peripheral and face milling.
- List four types of knee and column type milling machines.
- 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?

Experiment-5

Study of Different Types of Operation in Grinding Machine

Objectives:

- Becoming familiar with the grinding machine and its various operations.
- Study of different types of grinding wheels.
- To learn about proper safety measures and their applications while using the machine.

Apparatus:

- Grinding machine
- Grinding wheels
- Work piece
- 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 uses as tool, primarily a hole finishing process.
- **Lapping**: Fine particles embedded in soft metal or cloth; primarily a surface-finishing process.

An abrasive is a 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

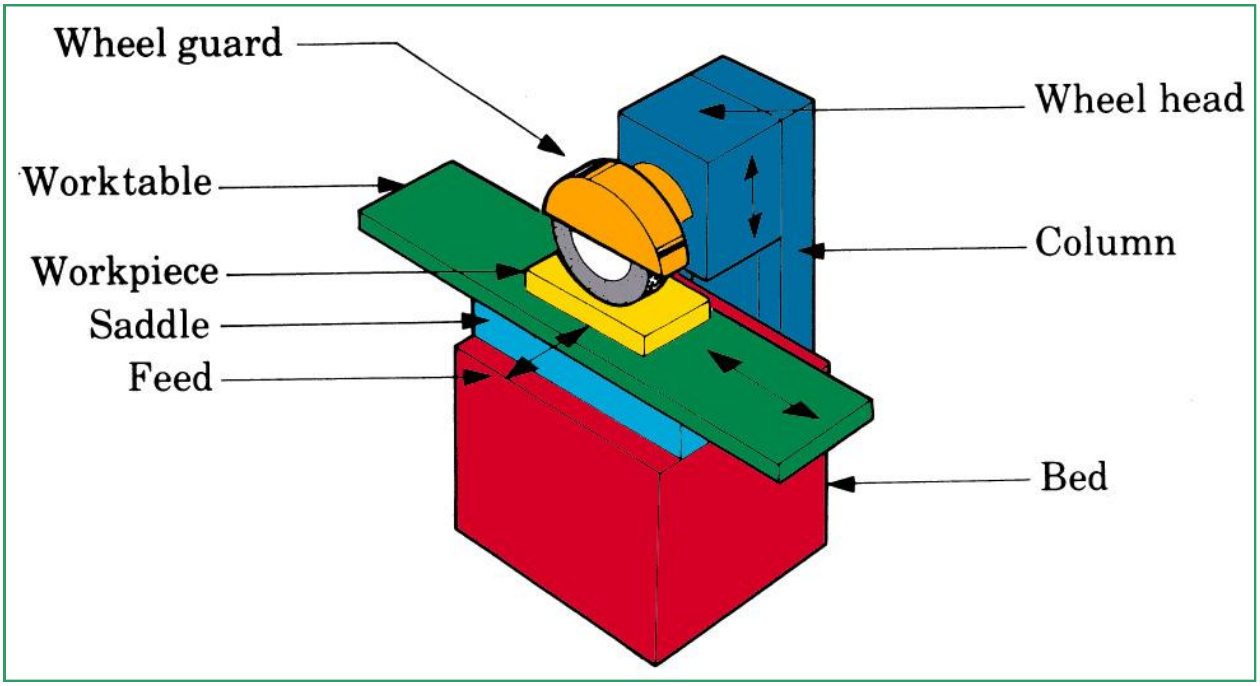


Figure 5.1: Schematic illustration of grinding machine

5. Wheel guard
6. Wheel head

Properties of Abrasives:

- **Penetration Hardness:** This property refers to tire ability of the scratch or cut a softer material.
- **Fracture Resistance:** This property refers to the abilityof an abrasive material to resist breaking or cracking under load.
- **Wear Resistance:** It refers to the ability of the abrasive grain to maintain sharpness. Wear resistance is largely related to penetration hardness and tensile strength of the abrasive.

Types of Abrasives:

- **Natural Abrasives:** Natural abrasives are obtained from nature. They are being replaced by artificial ones, Except for diamond, the natural abrasives are relatively soft in comparison to artificial abrasives. Some of the natural abrasives are:

1. Crocus: Reddish-brown oxide of iron and may be natural or synthetic.
2. Emery: Composed of corundrum (A1203) and 40% iron oxide and other impurities.
3. Diamond: The hardest material known, is used in the form of grains bonded together to form an abrasive stick or grinding wheel.

- **Artificial Abrasives:** They are harder and have greater impact toughness than any natural abrasives except diamond. The commonly used artificial abrasives are Silicon Carbide, Aluminum Oxide, Boron Carbide, Synthetic diamond etc.

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 the kind and size of abrasive, how closely the grains are packed together and amount of the bonding material.

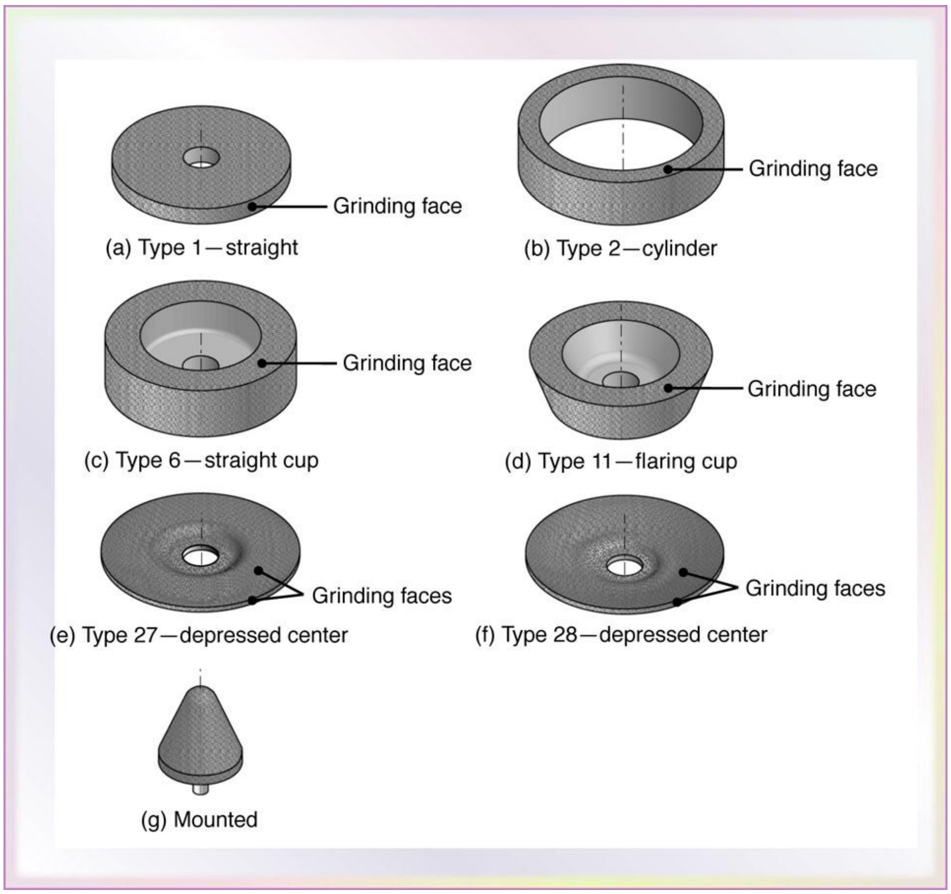


Figure 5.2: Common types of grinding wheels

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.

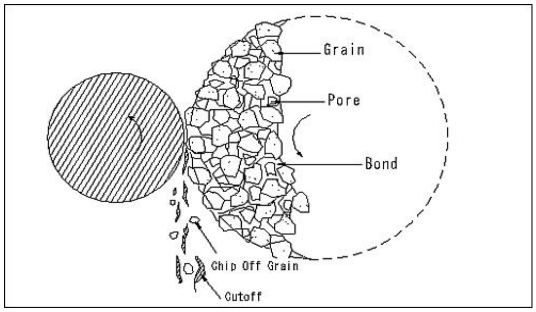


Figure 5.3: Cutting action of wheel

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 1.5mm or more.
- **Finish Grinding:** On finish-grinding operations, grinding wheels remove metal relatively slowly in comparison with other cutting tools. Finish grinding usually follows other rough-machining 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
  - **External cylindrical grinding**
  - **Internal cylindrical grinding**
  - **Surface grinding**

Surface grinding: It is most common of the grinding operations. A rotating wheel is used in the grinding of flat surfaces. Types of surface grinding are vertical spindle and rotary tables.

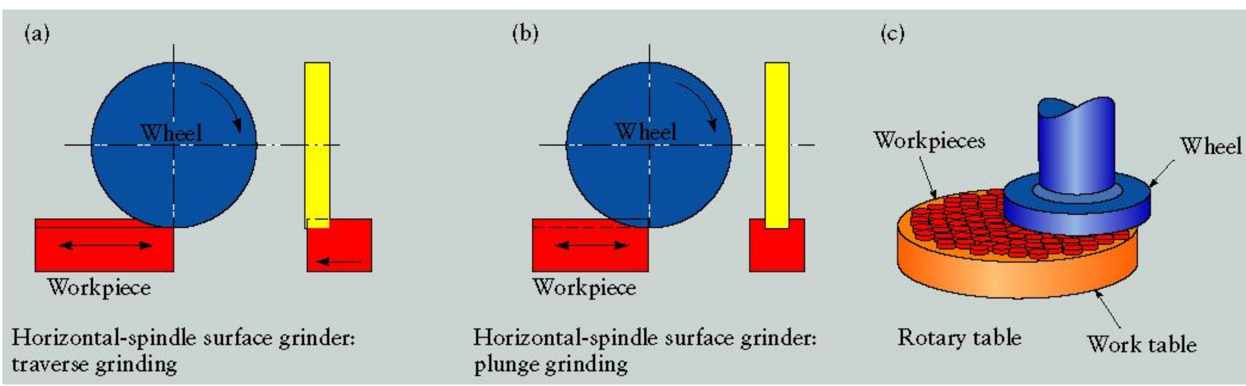


Figure 5.4: Different types of grinding operations

Cylindrical grinding 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.

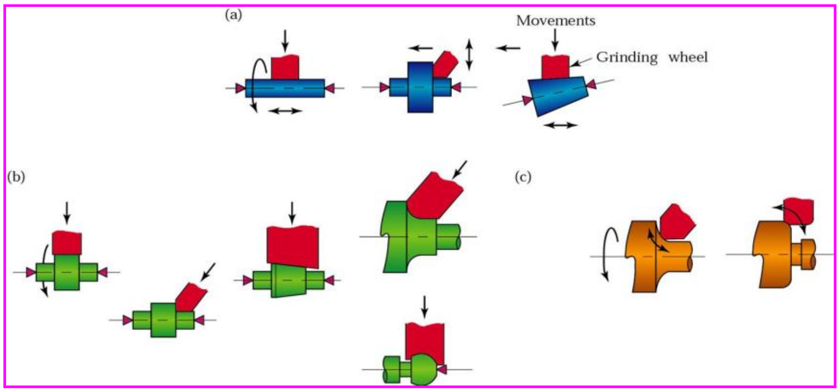


Figure5.5: Examples of various cylindrical grinding operations. (a) Traverse grinding, (b) plunge grinding, and (c) profile grinding.

Internal grinding 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.

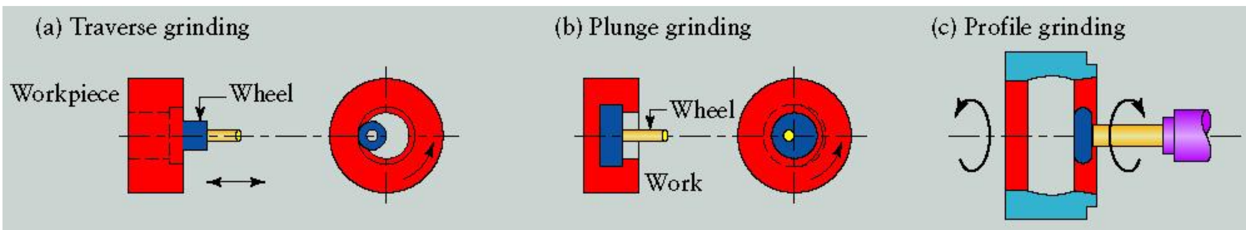


Figure 5.6: Schematic of Internal Grinding

Turing of Grinding Wheels:

A grinding wheel should be trued each time it is put on the spindle. It should be dressed whenever it becomes dull, loaded or grazed with use. Turing refers to correcting an out of round condition of the wheel. A dressing tool is used to remove particles of the abrasive from the high part of wheel. Turing also refers to remove particles of the abrasive from the high part of the wheel. Turing also refers to forming the wheel to a particular shape, such as concave or convex. To be in good condition, the wheel must be sharp and run true on both the periphery and the sides.

Dressing produces a sharp grinding surface. A diamond tool is used to remove the dull or loaded surface of the wheel. Dressing is necessary whenever the wheel cuts poorly, usually resulting in burning the work.

Calculation of Grinding Ratio:

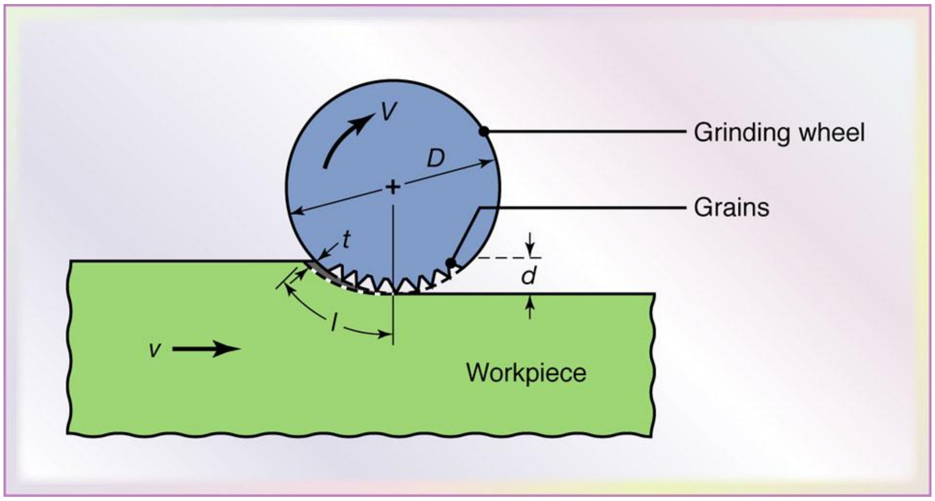


Figure 5.7

Where,

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

Assignments:

- 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-6:

Study of Shaping Machine, Its Various Operations and MRR calculation

Objective: The objective of this experiment is to get familiar with shaper machine, its operation and calculation of material removal rate.

Apparatus:

- Shaper machine
- Vice
- Job
- Single point cutting tool

Shaper Machine and its components:

Ram: The ram slides back and forth in dovetail or square ways to transmit power to the cutter. The starting point and the length of the stroke can be adjusted.

Toolhead: The toolhead is fastened to the ram on a circular plate so that it can be rotated for making angular cuts. The toolhead can also be moved up or down by its hand crank for precise depth adjustments.

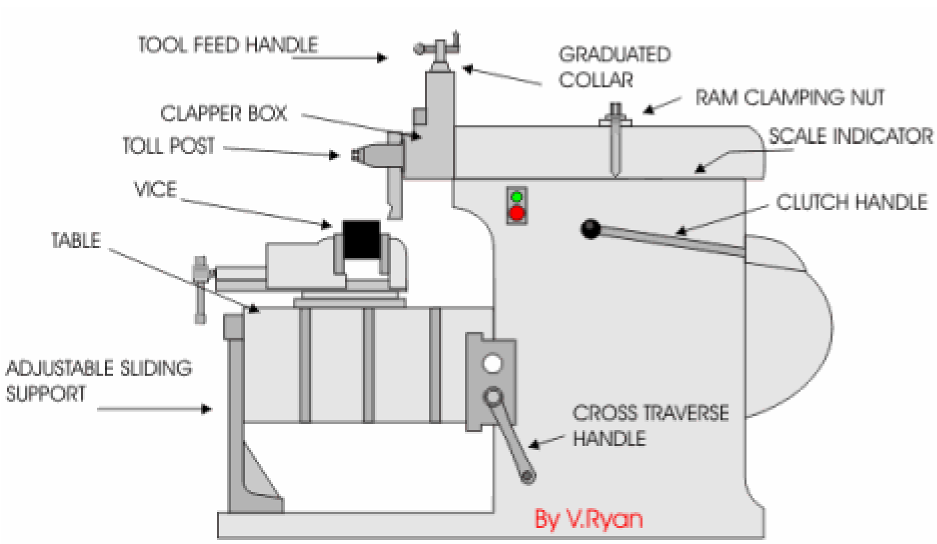


Figure 6.1: Shaping machine

Clapper Box: The clapper box is needed because the cutter drags over the work on the return stroke. The clapper box is hinged so that the cutting tool will not dig in. Often this clapper box is automatically raised by mechanical, air or hydraulic action.

Table: the table is moved left and right, usually by hand, to position the work under the cutter when setting up. Then either by hand or more often automatically the table is moved sideways to feed the work under the cutter at the end or beginning of each stroke.

Quick Return Mechanism

The shaping machine is used to machine is used to machine flat metal surfaces especially where a large amount of metal has to be removed. Other machines such as milling machines are much more expensive and are more suited to removing smaller amounts of metal very accurately.

The reciprocating motion of the mechanism inside the shaping machine can be seen in the diagram. As the disc rotates the top of the machine moves forwards and backwards pushing a cutting tool. The cutting tool removes the metal from work which is carefully bolted down.

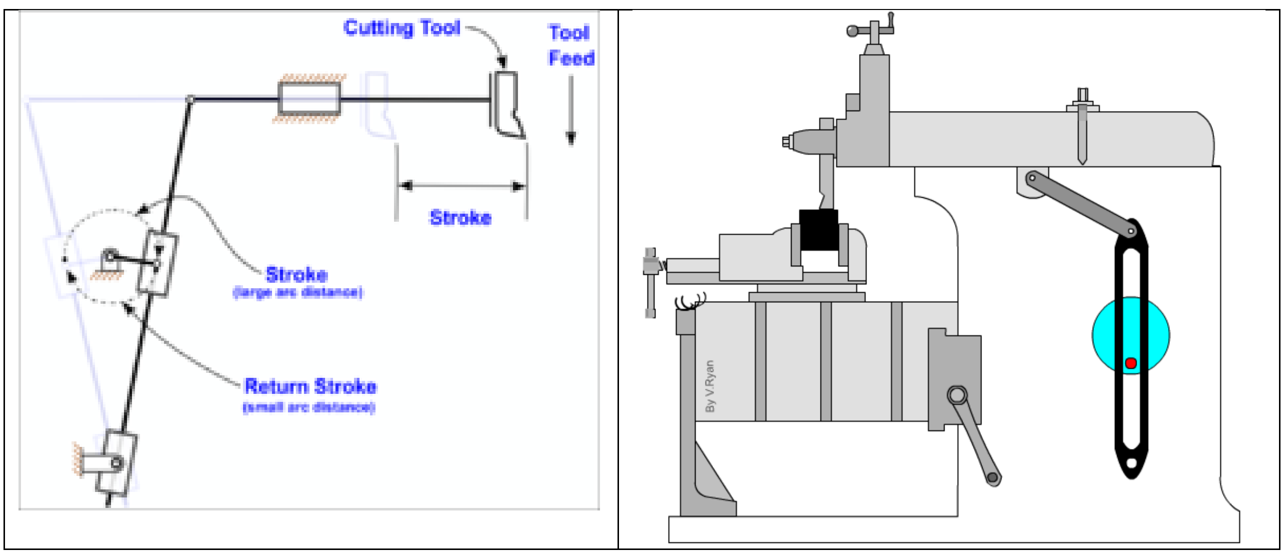


Figure 6.2: Quick return mechanism

Various cutting operations that can be performed on a Shaping Machine

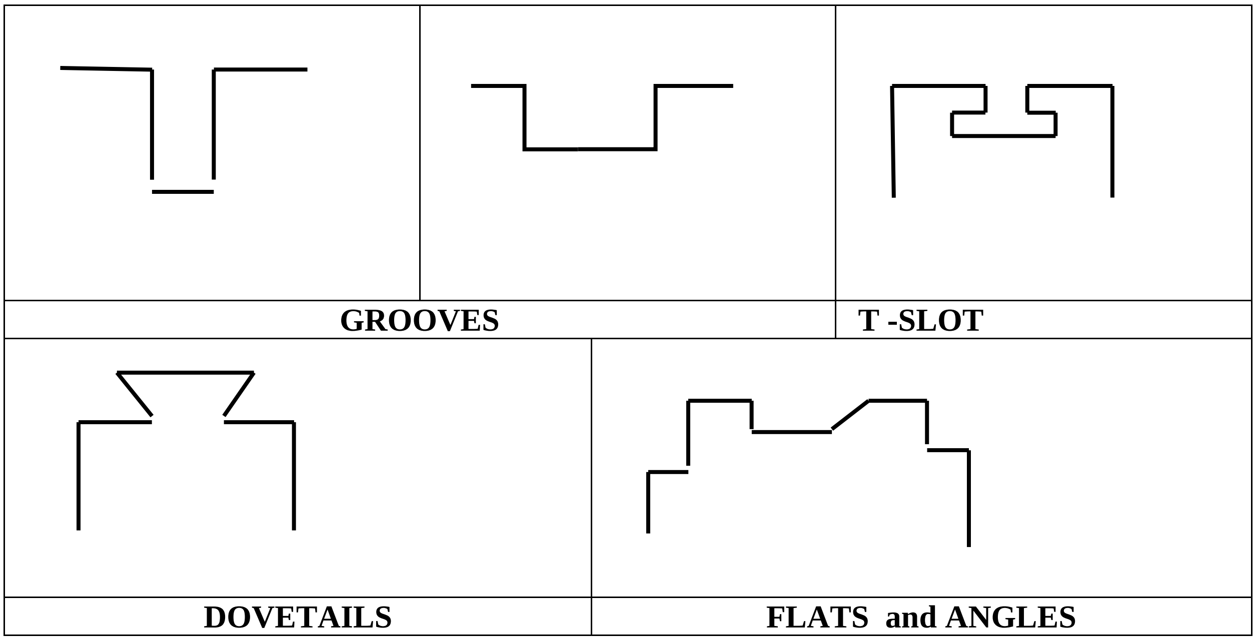


Figure 6.3

Calculation of MRR (Material Removal Rate):

MRR = d . w. t / total machining time

where, d = length of job

w = width of job

t = depth of cut

Assignments:

- Explain quick return mechanism with neat sketch.
- Difference between shaper and planer machine.
- How many degrees of freedom are there in a shaper machine?
- What are functions of the clapper box?
- What are the advantages and disadvantages of high MRR?

Experiment-7

Study of Injection Molding Machine and its operations

Objectives:

- Becoming familiar with injection molding machine.
- To learn about plastic processing operation.
- Learning about common injection molding defects.

Process Description:

The plastic melt flows from the injection nozzles and enters the mold at the sprue. From the sprue the plastic flows into the runners and ultimately through the gates into the part. Gate and runner design is an important part of the mold design. To help ensure that the mold fills completely, one should balance the mold so that all cavities fill at the same time. When the cavities are the same, a symmetric layout is used. If the cavities are all markedly different, often the gates and runners must be sized/shaped differently in order to allow all cavities to fill in the same amount of time.

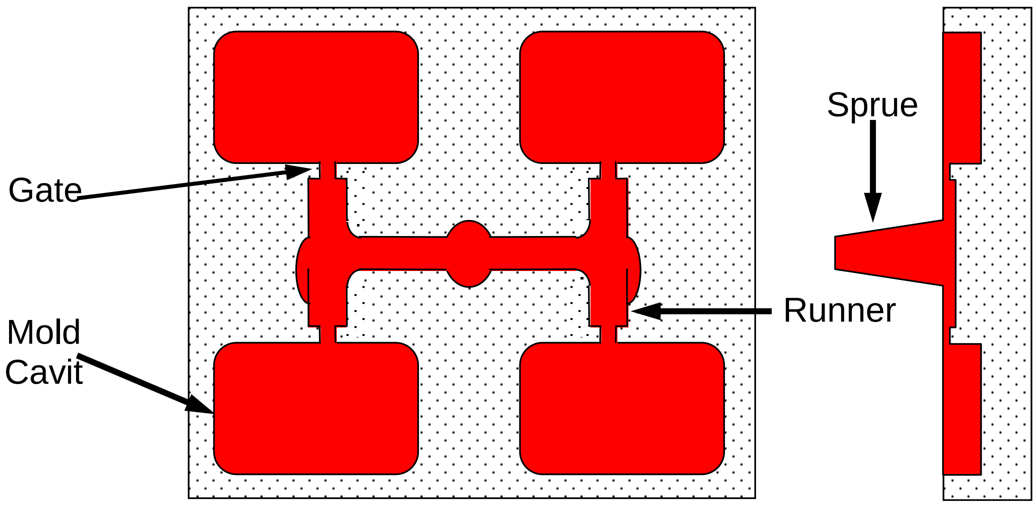


Figure 7.1

There are two basic types of injection molding press.

1. Plunger type
2. Screw type

Screw Type Injection Presses: The original plunger type has had one important modification. A reciprocating screw now forces material into the mold. This screw action ensures that the same amount of material is always metered in, and it is equally dense along the length of the screw. Additionally the material will be much better mixed by the screw action which helps to maintain better consistency from shot to shot. Since the screw action generally helps to pack the material in better, a given plunger travel will push more material into the cavity. Finally the action of the screw, as it rotates and mixes, adds energy to the melt. However, band heaters are still needed to fully heat the melt. All of this results in a much better and more consistent part. This is why the screw press is essentially the only press found in industry. Small plunger presses are still made for prototype/lab purposes.

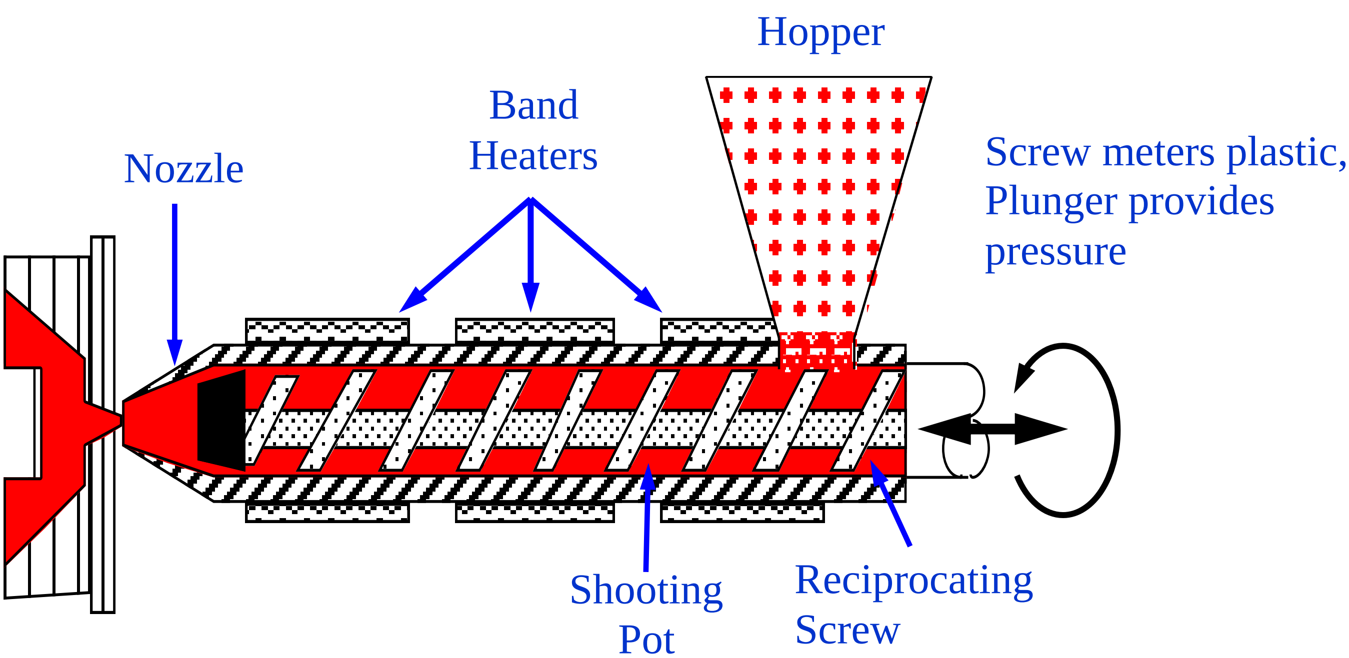


Figure 7.2: Schematic of Injection molding press

The injection molding screw plunges forward to provide holding and packing pressure. The screw rotates as it retracts to meter and plasticize the melt. The screw is broken up into 3 regions. The Feed Section draws material from the hopper and starts movement into the shooting pot. In this section, channels between the flights are deep and the depth is constant. The next section, called the Transition Section, compresses and melts the plastic pellets. Most plasticization occurs in this section. The root diameter tapers, causing the channel depth to decrease. In the last section, the Metering Section, the correct fill is precisely measured out. This section has a constant channel depth.

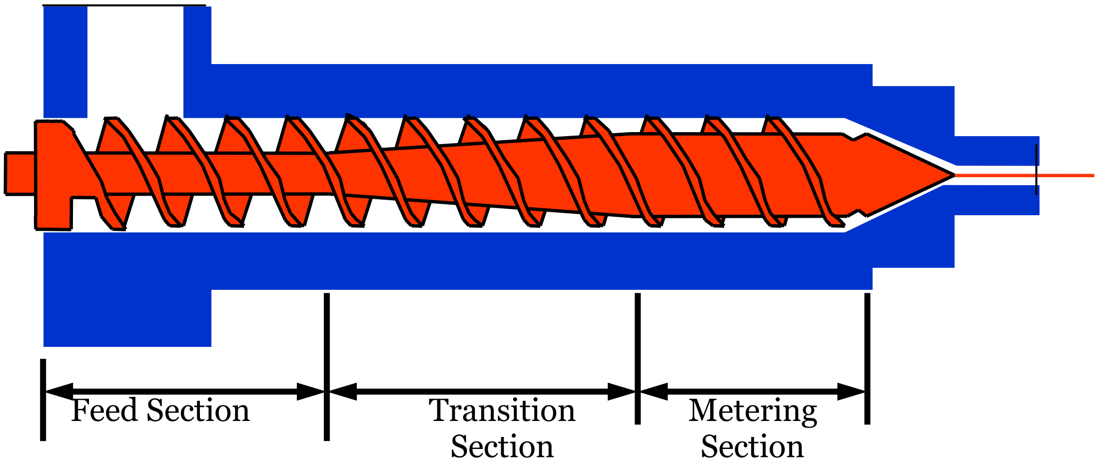


Figure 7.3: Different section of the Injection molding machine

Plunger Type Injection Molding Press: In this molding press, the plastic is fed into the mold when a cylinder plunger extends and forces the plastic into the mold. After the plunger retracts more material can be fed from the hopper to the shooting pot. (Thus the stroke of the plunger determines the additional material fed in each time.) Of course the shooting pot is long enough to hold several shots, so the plastics stays in the pot for a while, giving the band heaters time to heat and melt the plastic. Notice the torpedo, which is basically an obstruction to the plastic flow in the shooting pot. As the plastic moves around the torpedo, it is better mixed.

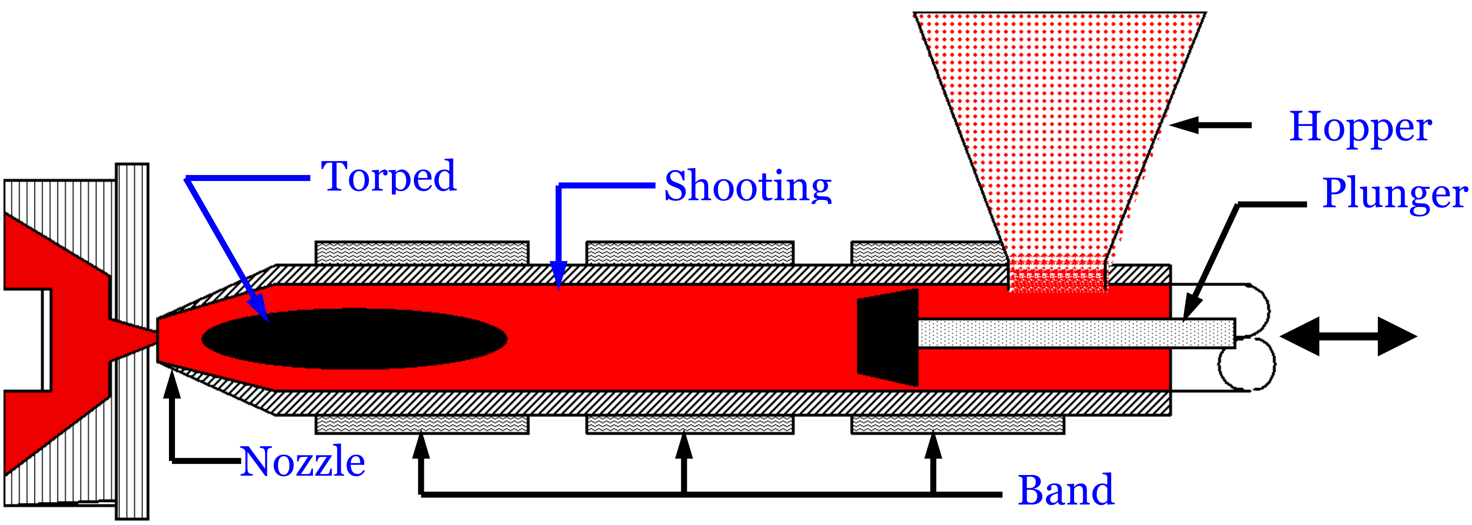


Figure 7.4: Schematic view of Plunger type Injection Molding Machine

Generally, there are three common parameters used to describe the injection molding press capacity: **clamping force**, **shot size**, and **injection pressure**.

- **Clamping force** is usually the most common method to refer to the injection molding press capacity. Thus, presses are talked about as being 20 ton, 50 ton, etc. The clamping force is the force available to hold the platens together.

- **Shot size** is the amount of material that can be transferred into the mold in one shot. Shot sizes are usually specified in cubic centimeters or ounces.
- **Injection pressure** is the pressure at the sprue that forces or injects the plastic melt into the mold. Specification by this parameter refers to the maximum injection pressure.

Injection Molding Defects:

- **Short Shot**
- **Flashing**
- **Weld Lines**
- **Jetting**
- **Ejector Pin Marks**
- **Sink Marks**
- **Warpage**

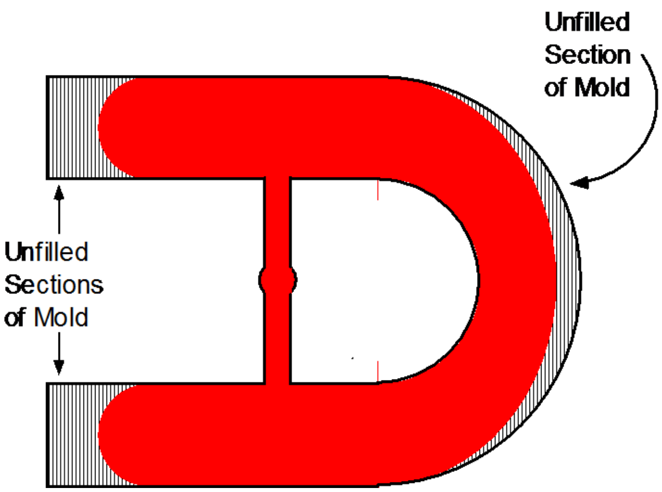


Figure 7.5: Short shot

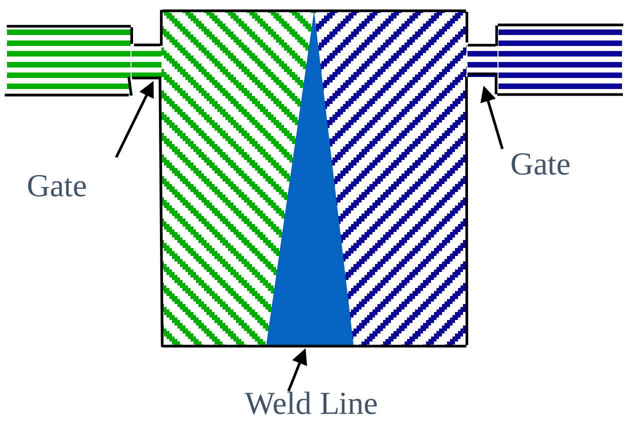


Figure7.6: Weld line

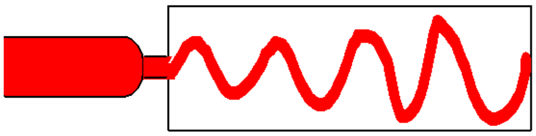


Figure7.7: Jetting

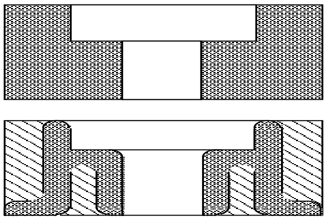


Figure 7.8: Sink marks

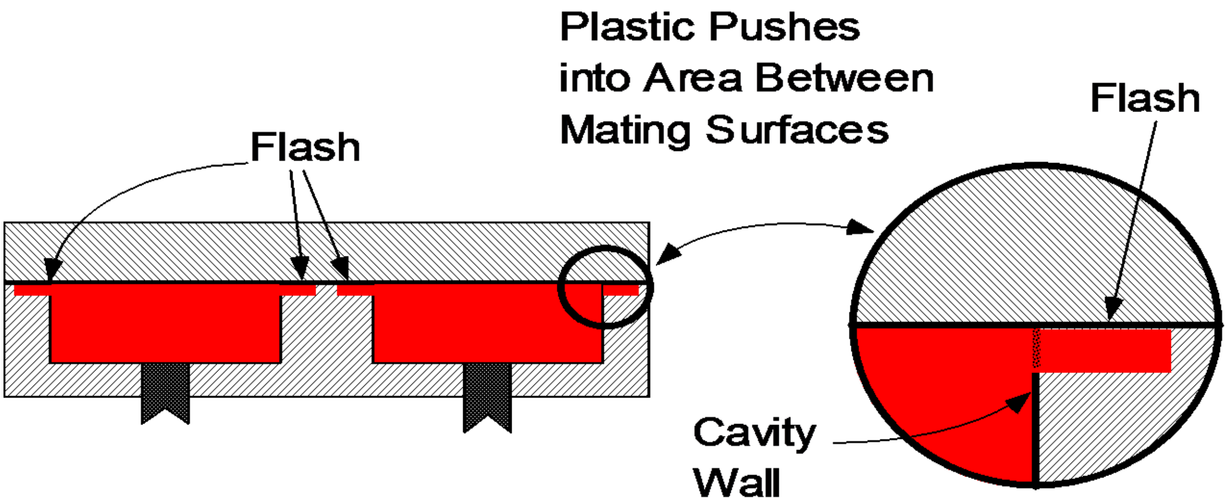


Figure 7.9: Flash

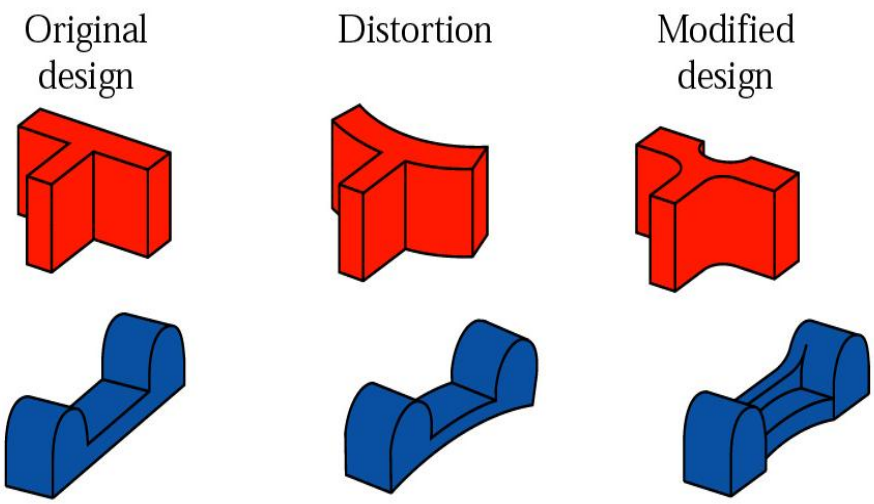


Figure 7.10: Warpage

Short Shot: Short shot occurs when there is insufficient material to fill the mold cavity and/or the material solidifies too soon. It has several causes, including insufficient injection pressure, or insufficient time allowed during the injection process. Sometimes the material will freeze in a given section before it can reach the edges of the mold.

Flashing: Flashing occurs when there is too much material and it pushes its way out of the die; basically, the material overflows the cavity. This can be caused by too much injection pressure, too much injection time, or insufficient clamping force. It also can be caused by a poorly machined die that does not properly seal off the cavity.

Weld Lines: Weld lines occur when flow fronts meet in the mold. In addition to being aesthetically unappealing, weld lines decrease the strength of the part. This normally occurs around holes or obstructions and causes very weak areas in the molded part. Additionally, weld lines are much more pronounced if flow fronts are moving in completely opposite directions, as opposed to when the flow fronts share some components of velocity. Weld lines are more pronounced if melt is cooler when fronts meet.

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Jetting: Jetting is generally caused when one gates a part in such a way that the material flow enters an open section with much space between the gate and the opposite wall. When the flow area is squeezed through the gate, the velocity increases, and the plastic melt shoots into the empty cavity mold.

To reduce the risk of jetting, one should always gate the part so that incoming material flow is directed into a nearby wall. After the stream has impinged on the wall, the plastic melt will spread in the appropriate fashion. Melt moves rapidly, cools unevenly and traps flow lines.

Sink Marks: Sink marks are also common injection molding flaws. Sink marks occur at excessively thick wall sections, or where there are abrupt changes in thickness- thick sections solidify too late and shrink away from the wall. Proper design reduces/eliminates sink marks (ribs, core out sections)

Warpage/Residual Stresses: Warpage is the “out of plane” distortion of an injection molded part, generated by constraining the part while cooling. Warpage is typically caused by anisotropic shrinkage. Several causes for anisotropic shrinkage are: Variations in thickness, Differing shrink rates due to melt orientation. Uneven cooling, Differences in the mold cavity pressure.

If the part is massive enough to resist warpage, residual stresses will result. Since gates are usually highly oriented and have extremely fast cooling rates, residual stresses are always present near the gates.

Assignments:

- What are the three sections of the injection molding screw? What are their features?
- Explain the three parameters that describe the molding press capacity.
- Differentiate between Plunger type and Screw type Injection Molding Machine.
- Explain the causes and remedies of common injection molding defects.

Experiment 8:

Study of Drilling Machine and Its Various Operations

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 than 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.)

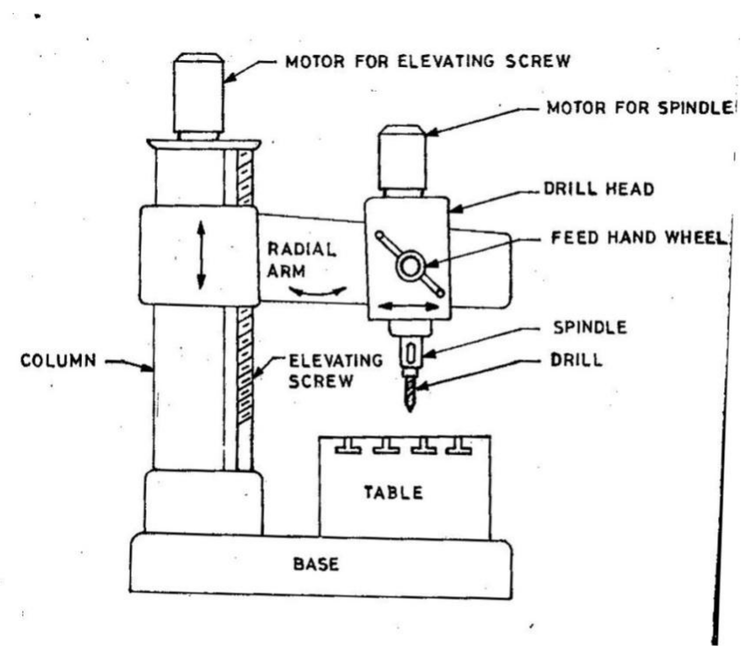
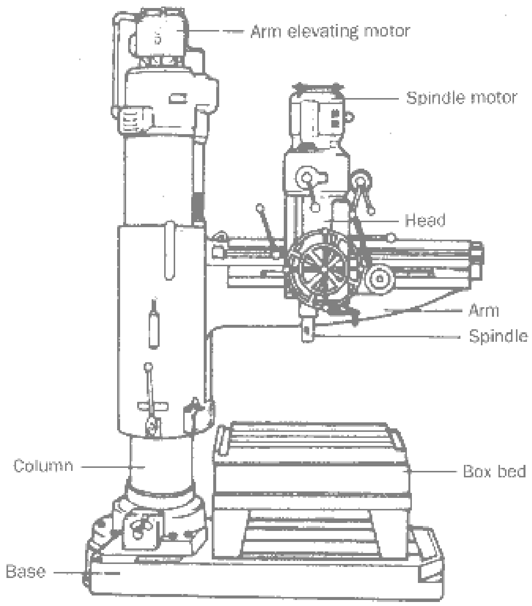


Figure 8.1

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



Radial drill machine Gang drill machine

Figure 8.2

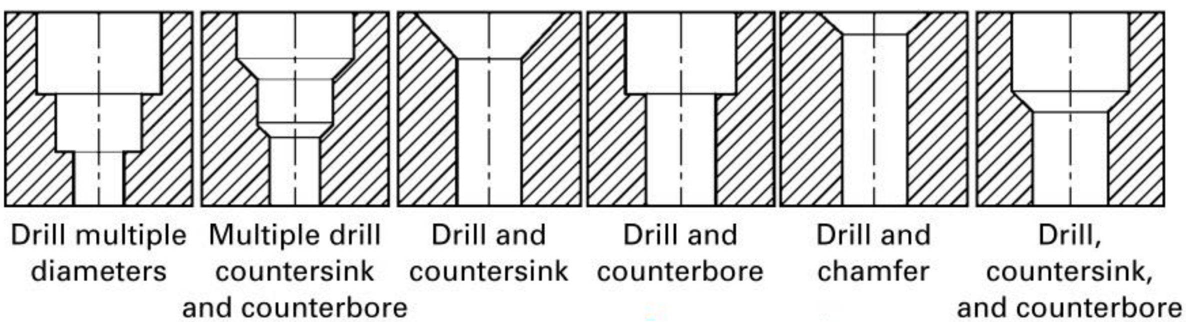


Figure 8.3: Various operations that can be performed on a Drilling Machine

Assignment:

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

b) What are degrees of freedom of a drill machine?