

MP

Manufacturing process

Foundry

A foundry refers to a facility or operation where metals are melted and cast into specific shapes or forms. Foundries are used to produce a wide range of products, from small parts like engine components to large number structures like engine blocks and industrial machinery. The process allows for the creation of complex shapes that might be difficult or expensive to achieve through other methods like machining or forging.

Safety precautions in foundries

- 1) PPE - Heat-resistant clothing, gloves, goggles, ear protection and steel-toe boots.
- 2) Proper Ventilation: To control fumes, gases and dust.
- 3) Equipment Safety: Regular maintenance, emergency shut-off and careful handling of molten metal.
- 4) Workplace Organization: clear pathways, warning signs, fire safety systems.
- 5) Safe chemical Handling: proper storage, labeling, and disposal of hazardous materials.
- 6) Training - Regular worker training

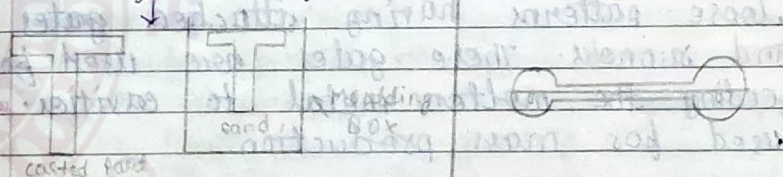
Casting - It is the actual MP where molten metal is poured into a mold to solidify and take the shape of the mold.

Pattern - refers to a model or replica used to create molds for casting metal or other materials.

Types of patterns

- 1) Solid or single piece pattern
- 2) Split or two " "
- 3) Loose " "
- 4) Match plate " "
- 5) Gated " "
- 6) Sweep - another " "
- 7) Skeleton " "

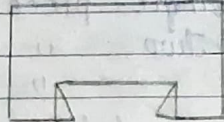
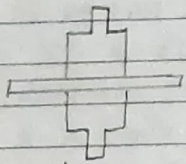
used when casting is symmetric
1) solid piece pattern - made by single piece and has no joints, cheap & easy to construct and limited in use, used for simpler castings with few details.



2) Two piece pattern: Pattern divided into ^{two} or more parts which are joined at the parting by ^{sand} bowl pins to form a mold cavity, common in casting. ~~p~~ used ~~is~~ for complex shapes

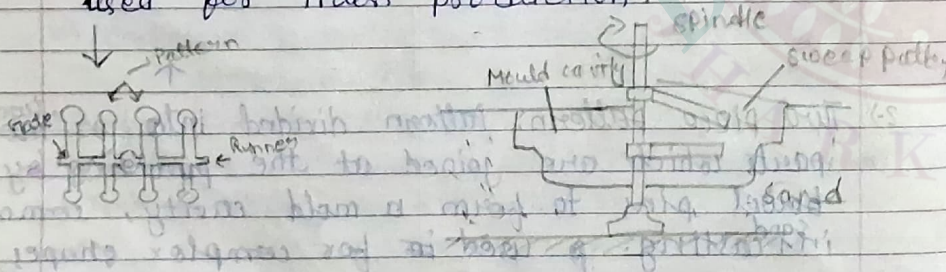
3) Loose piece pattern - includes detachable parts (piece - pieces) to create complex shapes, or undercuts that it consists of multiple

expensive due to highly skilled job
separate pieces used to create a mold. After casting process, they are removed to leave behind cavities or features in the final cast part.



4) Match plate pattern - used in sand casting process. It consists of two halves mounted on a metal plate, which is used to form a mold for casting. Use: efficiency, reusability.

5) Grated pattern - made by one or more loose patterns having attached gates and runners. These gates are used for feeding the molten metal to cavities. used for mass production.

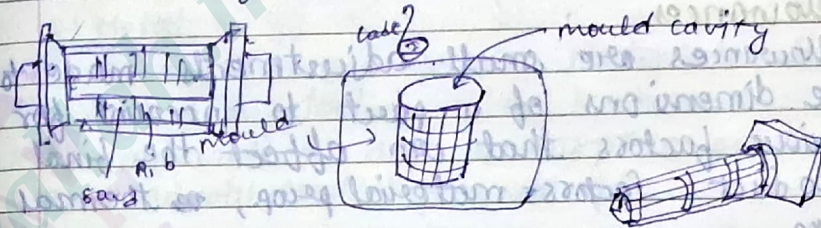


6) Sweep pattern - a simple wooden form that rotates around a fixed axis to shape symmetrical molds.

- large saving in time, labour, and material
- used for large, symmetrical casting like cylindrical or spherical shapes.

7) skeleton pattern

the basic framework or outline used to guide the production of a product. a skeleton pattern can refer to a rough shape of the object to be cast.



s.p is more economical as compared to solid pattern because it involves less material cost. consisting of wooden frame and strips
- used for small no. of large casting
- Appli - oil pipes, soil and water pipes, pipe bends, turbine casing

steps involved in the metal casting process:-

- 1) Pattern making:- A wood or metal piece replica of the part is used to create the mold.
- 2) Melting:- The metal is melted in a furnace at high temp.
- 3) Pouring - The molten metal is poured into

the mold.

4) Removing - The casted part is removed from the mold after it solidifies.

5) Finishing - The part is ground, machined and sanded to achieve the desired shape and surface finish.

Allowances

Allowances are small adjustments made to the dimensions of a part to account for various factors that can affect the final product. Factors: material prop., thermal exp.

Types of allowance

1) Shrinkage allowance - The reduction in vol. when metal changes from liquid to solid.

Ex - W.C.I - 2mm/m Cu/Brass/Al = 16mm/m

Gr. C.I - 10mm/m

Types - liquid and solid

2) Draft allowance - It is a taper allowance to be given to the pattern for easy removal from mould.

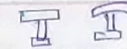
3) Finish/Machining allowance - for better surface finish, this allowance is given.

range - 2mm to 15mm

4) Rapping / shake allowance - The mould flask is to be rapped for shake before

shake allowance of increasing taper

irregular shape, all parts uniformly not shrink, U or V more, some parts unequal thickness, long hot casting, one portion is cooling faster rate as compared to other.



removal.

5) Distortion / chamber allowance - occurs when a part changes shape or size due to internal stresses, thermal exp. or other factors.

Materials used for pattern

1) Wood

C - Traditional, easy to machine.

Ap - Common for sand casting.

Ad - Easy to modify, lightweight, inexpensive.

2) Metal

C - Durable and precise materials like Al, Cu and steel.

Ap - automotive and aerospace parts.

Ad - can withstand higher temp.

3) Plastic

C - Lightweight and.

Ap - precision casting, prototype parts.

Ad - can create detailed parts with good dimensional acc., lightweight, cost.e.

4) Wax

C - Lost-wax casting (investment casting).

Ap - jewelry and small precision parts.

Ad - high acc.

5) Elastomer

C - investment cast.

Ap - jewelry, medical devices, art pieces.

Ad - produces smooth surface.

classification in MP.

- 1) Casting → 2) Forming → 3) Material removal process → 4) Fabrication processes
- Primary Secondary

Sand casting

It is a widely used metal casting process that involves pouring molten metal into a mold made of sand. Pattern → mold formation → Pattern removal → metal pouring → cooling and removal.

Adv. - can cast complex shapes

- 2) inexpensive process
- 3) used for a variety of metals, alloys
- 4) used for to quickly produce prototype parts

Disadv. - low accuracy, limited size, High labor cost, environmental concerns.

Appl. - Automotive parts, Aerospace, Industrial, etc.

Parts of the sand casting

- 1) Pattern - A replica of the part to be cast typically made of metal, wood or plastic.
- 2) Mold Box (flask) - A container (cope and drag) that holds the sand mixture to form the mold.

It is a refractory material used for making mold mixture of silica, clay and water with appo. prop. to get the desired consistency.

3) Sand - The primary material used to make the mold, mixed with a binder.

4) Binder - A material (like clay) that holds the sand particles together.

5) Core - A sand form placed inside the mold to create internal cavities or hollow sections in the casting.

6) Sprue - The channel through which molten metal is poured into the mold.

7) Runners and gates - channels that direct flow of molten metal into the mold cavity.

8) Vent - Small openings that allow air to escape during pouring.

9) Pouring Basin - The reservoir where molten metal is poured into the mold.

10) Riser - It is a reservoir of hot molten metal used to facilitate the flow of hot metal back into mold cavity when there is a reduction in vol. of metal due to solidification.

6) Sprue - It is the passage through which the molten metal from the pouring basin reaches the mold cavity. It is a vertical channel which connects the pouring basin to the runner.

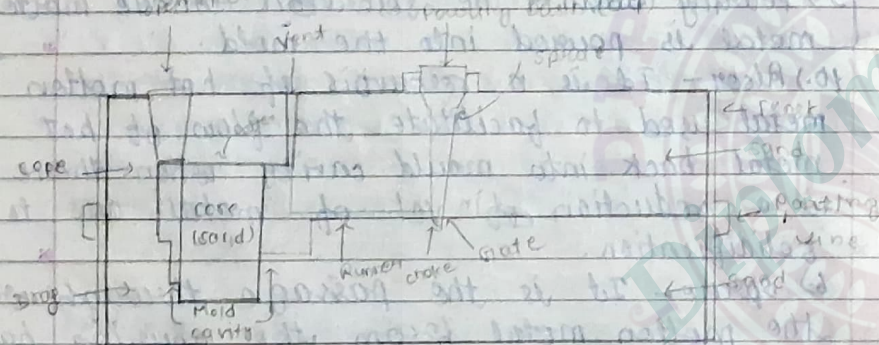
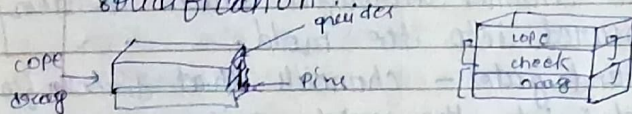
9) Pouring basin - It is a small funnel shaped cavity at the top of mold into which the molten metal is poured.

11) Chaplets - used to support cores inside the mold cavity to take care of weight of core and overcome the buoyancy from

molten metal.

12) ^{Mould} Mold - It is the structure which is made with the help of pattern. It contains cavity of size similar to object being cast.

13) chill - metallic structure used to conduct ~~away~~ heat ^{away} from the casting during its solidification.



Mold - American
mould - British

CH - 2

1# Molding sand - Types

It is a type of sand used in the sand casting process to create molds for casting metal parts.

• Properties

- 1) Refractoriness: M.s. must be able to withstand the high tempⁿ of molten metal without breaking down or losing its shape.
- 2) Cohesion and strength. - The sand must be held together during moulding and pouring of molten metal. This prop. ensures that the mold doesn't break apart under pressure.
- 3) Permeability: Molding sand must allow gases (like air or steam) to escape during the pouring of molten metal, prevents casting defects.

$$P. no. (P) = \frac{V \times H}{p \times A \times T}$$

where, P = permeability no.

V = Vol. of air passing through specimen (cm³)

H = Height of specimen (cm)

p = Pressure of air (g/cm²)

A = cross-sectional area of specimen (cm²)

T = Time taken for air to pass (min)

- 4) Plasticity - Molding sand must have a certain level of plasticity.

5) Grain size - size of the sand particles affects the smoothness of the mold surface. Finer sand results in a smoother surface finish for the casting.

• Types

1) Green sand

prop - contains moisture (3-5%), clay bonded (8-12%) commonly used, reusable.

C. - silica sand (85-90%), clay (bentonite), water, Additive

Ad. - Economical, easy to prepare, high prod. rate.

disad. - lower strength, limited life, moisture control needed.

2) Dry sand

prop. - green sand that's been dried, no moisture content, higher strength, better surface finish.

p. - mold made with green sand dried at 200-300°C creates harder surface, better dim. acc.

ad. - Higher strength, better finish, more accurate, less gas problems.

disad. - Higher cost, time consuming.

3) Chemical sand

prop. - uses chemical binders like phenolic resins, epoxy resins

No clay or water, chemically hard, high strength.

Ad. - Excellent strength, superior finish, better acc., & less defects.

disad. - Expensive, limited reuse, environmental concerns, storage issues.

4) Core sand:

prop. - makes internal cavities, higher reusability, special binders, greater strength.

C. - High-quality silica sand, special binders, additives for strength, No clay/moisture

Ad. - Greater internal cavities, strength, fine grain size, reusable

disad. - more expensive, complex preparation, shrinkage, additional equipment for creating cores

Ingredients

1) Silica sand (SiO_2): - provides bulk, heat resistance and strength to the mold

2) Clay - acts as a binder, which bonding agent, like bentonite, that holds the sand particles together, controls plasticity

3) H_2O - 2-4%, activates clay, controls moisture

4) Fines - fine particles that improve compactibility

5) Additives - optional materials like resins or fluxing agents to enhance prop., such as sea coal, Graphite, wood flour

Importance of core and core prints - gates, runners, and risers.

CORE:

- creates internal cavities in casting - made of special sand mixture - allows complex geometries - placed inside mold cavity.

CORE PRINTS:

- supporting seats for cores - provide alignment and location - prevent core movement during casting - ensure proper core positioning

GATES

- Metal entry points into mold - control metal flow - reduce turbulence - minimize air entrapment - Types: Top, bottom, side gates

RUNNERS:

- channels connecting gates to mold cavity - distribute molten metal evenly - reduce metal velocity - prevent early solidification - Assist smooth metal flow

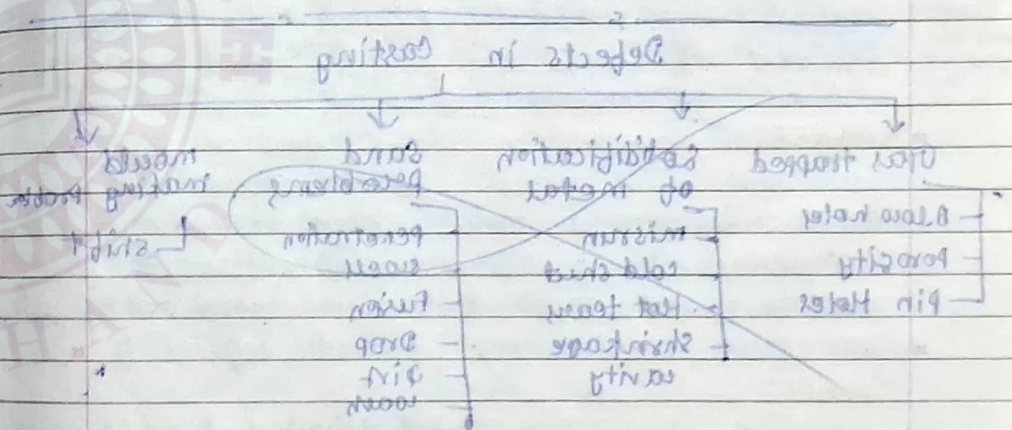
RISERS:

- Reservoir of extra molten metal - compensate for metal shrinkage - feed liquid metal to solidifying areas - prevent casting defects - Types: Open, closed, blind riser.

key functions

- Ensure quality casting - control metal flow - prevent defects - maintain dimensional accuracy.

Part in casting are subjected to defects. These defects can arise due to various reasons, including improper mold design, improper pouring technique, and cooling - solidification.

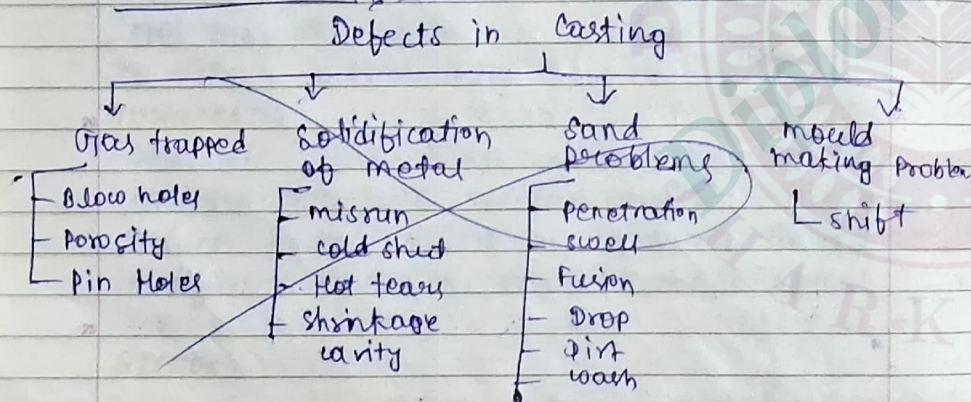


CH-3

- 1) Explain Defects in casting
- 2) Inspection of casting
- 3) Determination of production cost of a given material considering raw material, process cost, overheads and other expenses

1)

⇒ Defects in casting are irregularities that occur during the metal casting process, leading to deviation from the desired shape, size or quality of the final product. These defects can arise due to various reasons, including improper mold design, issues in the melting and pouring process and cooling irregularities.



1) Gas Trapped

- ☐ - Blow hole - Large open cavities caused by gas trapped in the molten metal.
- ☐ - Pin hole - small, closed cavities caused by gas trapped in the solidifying metal.
- ☐ - Porosity - small, interconnected pores located just beneath the casting surface.

2) Solidification of metal

- ☐ - Misrun - Incomplete filling of the mold cavity due to insufficient molten metal flow.

Defects in casting

Gas porosity	Shrinkage defects	Mold material defects	Pouring metal defects	Metallurgical defects
- Blow hole - Pin holes - Porosity	- Shrinkage cavity - Hot tears	- cuts and washes - Swells, drops - metal penetration	- cold shut - Misrun - slag inclusion	- Hot tears - Hot spots

2) Shrinkage Defects

- ☐ - Shrinkage cavity: A void formed due to the contraction of the metal during solidification.
- ☐ - Hot Tears: Cracks that occur due to stresses generated during cooling and solidification.

3) Mold material defects

- ☐ - Cuts and washes: Erosion of the mold surface due to the molten metal.
- ☐ - Swells: Bulges on the casting surface caused by gas pressure or mold material expansion.

- ☐ - Drops: Sagging of the mold material, resulting in a depression on the casting surface.
- Penetration: Molten metal seeping into the mold material, causing defects on the casting surface.

4) Pouring Metal Defects:

- ☐ - Cold Shut: A discontinuity caused by the meeting of two streams of molten metal that have not fused properly.
- ☐ - Misrun: Incomplete filling of the mold cavity due to insufficient molten metal flow.
- ☐ - Slag Inclusion: Non-metallic impurities trapped in the casting.

5) Metallurgical Defects:

- ☐ - Hot Tears: Cracks that occur due to stresses generated during cooling and solidification.
- ☐ - Hot Spots: Localized areas of high tempⁿ that can lead to defects like cracks or porosity.

Cause: Poor mold design, incorrect mold material, improper mold preparation, incorrect melting practice, incorrect pouring technique, poor casting design.

2) Inspection of casting

> Visual Inspection

- Purpose: To detect surface defects such as cracks, porosity, inclusions, surface roughness, or improper dimensions.

- Process: Inspect the casting visually under good lighting, sometimes using magnification for small defects.
- Tools: Magnifying lenses, inspection lights, and sometimes digital imaging.

> Dimensional Inspection:

- Purpose: To check if the casting meets the specified dimensions and tolerances.
- Process: Measure the casting using standard measuring tools like calipers, micrometers, or more advanced methods like coordinate measuring machine (CMM).
- Tools: Vernier caliper, micrometer, height gauge or CMM.

> Ultrasonic Testing (UT):

- Purpose: To detect internal flaws such as porosity, cracks, or voids.
- Process: High-frequency sound waves are transmitted through the casting, and the reflections (echoes) are analyzed to detect internal defects.
- Tools: Ultrasonic testing equipment with probe and transducer.

> X-ray or Radiographic Inspection:

- Purpose: To detect internal defects such as voids, inclusions, or cracks that cannot be seen from the surface.

- Process: X-rays or gamma rays are passed through the casting, and a film or digital detector captures the image of internal structure.
- Tools: X-ray or gamma ray machine, film or digital detector.

> Dye Penetrant Testing (DPT)

- Purpose: To identify surface-breaking defects like cracks or porosity.
- Process: A liquid dye is applied to the casting, and after a period, the excess dye is removed. A developer is applied, and any surface defects will show up with the dye.
- Tools: Dye penetrant solution, developer, UV light for detecting.

> Magnetic Particle Inspection (MPI)

- Purpose: To detect surface and slightly subsurface defects in ferromagnetic materials.
- Process: The casting is magnetized, and ferromagnetic particles are applied. If defects are present, the particles will gather around them, indicating their location.
- Tools: Magnetic yoke or coil, magnetic particles, and UV light for enhanced detection.

⇒ Inspection of casting is an essential process in ensuring the quality and integrity of cast metal parts. It involves various methods to detect defects, ensure dimensional accuracy and verify that the casting meets the desired outcomes.



3) Determinat... (Not available)

CH-4

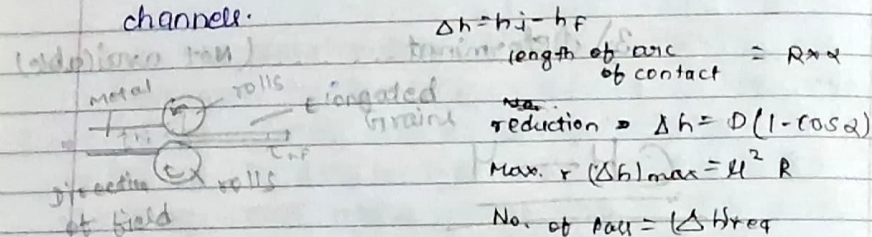
- 1) Introduction to basic Metal Forming process and applications - Show You.
- 2) Explain Hot and Cold working process with application
- 3) Introduction to forging operation - Types of forging - Hand forging and power forging

1) Metal forming is a manufacturing process that involves shaping metal materials into desired forms through plastic deformation. This process is widely used across various industries, from automotive to aerospace, due to its efficiency and ability to produce complex shapes.

The most common metal forming processes are:-

1) Rolling

- Process: Metal is passed between two rotating rollers to reduce its thickness and increase its length.
- Applications: Production of sheets, plates, coils, and structural shapes like I-beams and channels.



$$\Delta h = h_i - h_f$$

$$\text{length of arc of contact} = R \times \alpha$$

$$\text{reduction} = \Delta h = D(1 - \cos \alpha)$$

$$\text{Max. } r (\Delta h)_{\max} = \mu^2 R$$

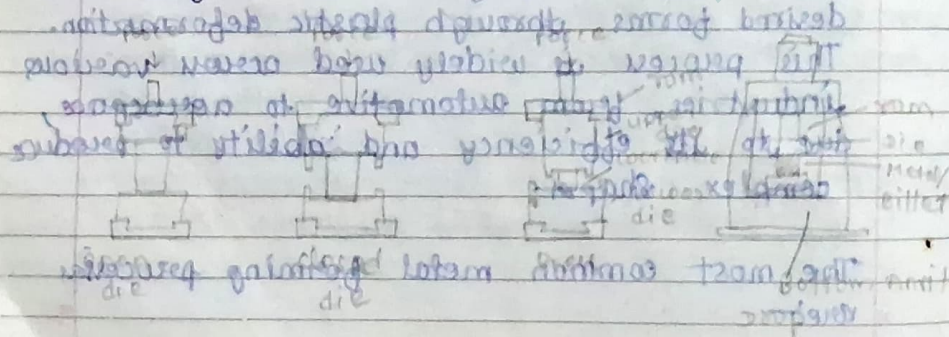
$$\text{No. of Passes} = \frac{(\Delta h)_{\text{req}}}{(\Delta h)_{\max}}$$

$$l_p = R \sin \alpha$$

$$= \sqrt{R \Delta h}$$

2) Forging

- Process: Metal is shaped by hammering or pressing it using compressive forces.
- Applications: Manufacturing of engine crankshafts, connecting rods, gears, and other high-strength components.

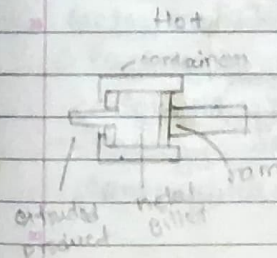


Types of rolling

- Based on Tempⁿ: Hot rolling, cold rolling, warm rolling.
- Based on product shape: Plate rolling, sheet rolling, section rolling, tube rolling, ring rolling.

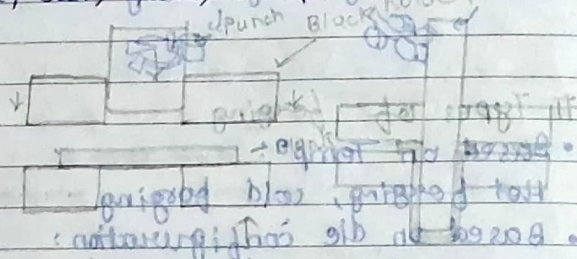
Types of forging

- Based on Tempⁿ: Hot forging, cold forging.
- Based on die configuration: Open-die forging, impression-die forging, roll forging, upsetting forging.
- 3) Extrusion
 - Process: Metal is forced through a die to produce a continuous shape.
 - Applications: Production of tubes, rods, wires, and profiles with various cross-sectional shapes.
 - Types: Hot, cold, direct (forward), indirect (backward), blown film.



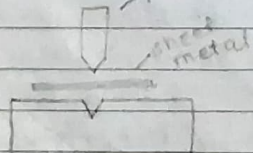
4) Drawing

- Process: Metal is pulled through a die to reduce its cross-sectional area.
- Applications: Production of wires, rods, and tubes with precise dimensions.
- Types: Wire, bar, tube, deep, cold-chamber die casting.

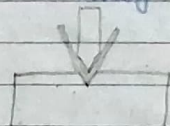


5) Bending

- Process: Metal is bent into a desired shape by applying a force.
- Applications: Manufacturing of sheet metal components like brackets, channels and U-shaped sections.
- Types: V-, air, roll (plate rolling), edge and corner bending.



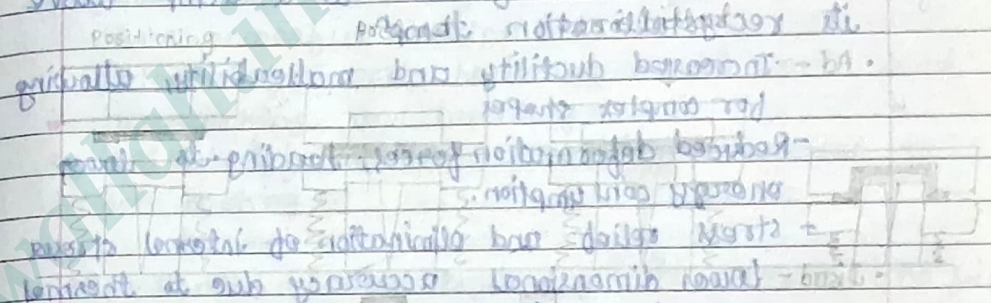
V-bending



Roll bending

6) Stamping

- Process: Metal sheets are shaped or cut using a die and press.
- Applications: Production of automotive body panels, kitchen utensils, and electrical components.
- Types: Blanking, piercing, drawing, embossing.



Applications

- 1) Automotive Industry: car body panels, chassis parts, engine components, wheels and rims.
- 2) Aerospace: aircraft body panels, engine parts, structural components, landing gear parts.
- 3) Construction Uses: structural beams, metal roofing, support columns, reinforcement bars.
- 4) Household products: kitchen utensils, appliance parts, furniture components, floor drains etc.
- 5) Industrial Equipment: Pressure vessels, storage tanks, machinery parts.
- 6) Packaging Industry: Metal cans, Bottle caps, containers, metal boxes.
- 7) Energy Sector: pipeline components, power plant parts, wind turbine parts.

> Advantages

Good Dimensional accuracy, high production rate, improved mech. prop., versatility.

2) Hot working and cold working

• Process - Metal is deformed at a tempⁿ above its recrystallization tempⁿ.

• Ad - Increased ductility and malleability, allowing for complex shapes

- Reduced deformation forces, leading to lower energy consumption.

- Stress relief and elimination of internal stress

• Disad - Lower dimensional accuracy due to thermal expansion and contraction.

- Potential for oxidation and scale formation on the metal surface.

- Requires specialized equipment and higher energy input.

• Applications -

• Forging: Producing large components like crankshafts, connecting rods, and gears.

• Rolling: Producing structural shapes like beams, channels, and rails.

• Extrusion: Creating long, continuous shapes like tubes, rods, and profiles.

cold working

• Process: Metal is deformed at a tempⁿ below its recrystallization tempⁿ.

• Ad - Improved mechanical prop. like strength, hardness, and wear resistance.

• Higher dimensional accuracy and better surface finish.

• No oxidation or scale formation.

• Disad - Increased deformation forces, requiring more powerful equipment.

• Potential for work hardening, which can lead to cracking and breakage.

• Limited deformation capability compared to hot working.

• Application: Rolling: Producing thin sheets and foils.

• Drawing: Creating wires and rods.

• Bending: Forming sheet metal components like brackets and channels.

• Stamping: Producing complex shapes like automotive body panels.

Feature	Hot working	Cold working
• Temp	Above recrystallization temp	Below recrystallization temp
• Ductility	High	Lower
• Deformation Forces	Lower	Higher
• Dimensional Accuracy	Lower	Higher
• Surface finish	Rougher	Smother
• Mech. prop.	Reduced	Increased (Strength, hardness, wear resist.)
• Grain structure	Refined	Distorted
• Oxidation	Potential for oxidation and scale formation	No oxidation or scale formation
• Applications	Forging, rolling, extrusion	Rolling, drawing, bending, stamping

3) Forging operation - Types of forging - Hand forging & power forging.

Forging is a metalworking process that involves shaping metal using localized compressive forces. This is typically done by hammering or pressing the metal, often while hot, using a hammer or die.

Why forging?

- Improved Mechanical prop.: Forging refines the grain structure of the metal, significantly

- increasing its strength, toughness and durability.
- Complex Shapes: Forging can create a wide range of complex shapes, from simple to intricate.
- High-Quality Products: Forged components are known for their reliability and

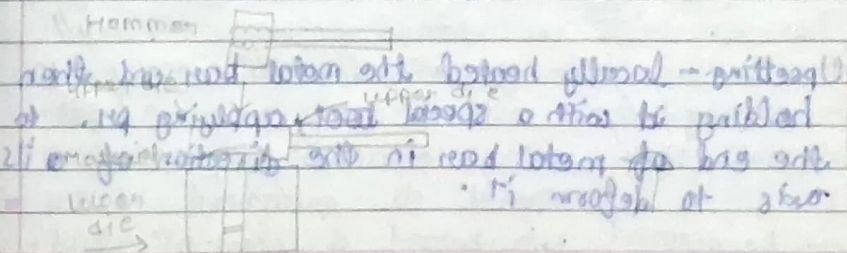
Types of forging

1) Hand forging - Hand forging is a traditional method where metal is shaped using hand tools like hammers and anvil.

Key steps

- 1) Heating: The metal is heated to a specific temp to make it malleable.
- 2) Shaping: The metal is shaped using hammer and anvil. Techniques - hammering, bending, drawing and upsetting.
- 3) Finishing: The forged piece is finished by grinding, filing, or polishing to achieve the desired shape and surface finish.

Applications - custom knives and tools - Decorative metalwork - Art and sculpture



2) Power forging

Power forging utilizes mechanical power to shape metal, allowing for greater precision, speed, and the production of larger and more complex components.

Types

- Open-die forging: Metal is shaped between flat or shaped dies.
- Closed-die forging: Metal is shaped between dies with impressions that define the final shape of the part.
- Impression die forging: Similar to closed-die forging, but with more complex die designs.
- Upsetting forging: Metal is shortened and thickened by compressive forces.

Applications

- High Production Rates: Power Forging can produce large quantities of parts efficiently.
- Precise Dimensions and Tolerances: Power forging can achieve high levels of accuracy.
- Complex Shapes: Power forging can create intricate shapes that are difficult to produce with other methods.

Upsetting - Locally heated the metal bar and then holding it with a special tool, applying pr. to the end of metal bar in the direction of its axis to deform it.

CH-05

- 1) Explain forging operations - Upsetting, drawing down, Cutting, Bending
- 2) Explain Punching and Drifting, setting down and finishing, forge welding
- 3) Estimated - - - - - ?

* **Forging operations**:- Forging is a metalworking process in which a metal piece is shaped by applying compressive forces, typically using a hammer, press or die. It alters the shape of the material, improving its mechanical properties such as strength and toughness.

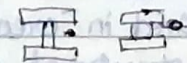
Below are explanations of the key forging operations are:-

1) **Upsetting**:- upsetting is the process of increasing the diameter (or cross-sectional area) of a metal workpiece by compressing it along its axis.

• **How it works**:- The metal is heated and compressed, causing it to shorten in length but thicken in diameter.

• **Applications**:- Commonly used to form head on bolts, rivets or nails.

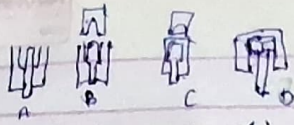
• **Example**:- Forging the head of a nail from a cylindrical metal rod.



2) **Drawing Down / or Drawing out**:-

• **Def**:- Drawing down involves reducing the cross-sectional area (thinning) of a metal workpiece while increasing its length.

• **How**:- The metal is heated and hammered or pressed



- Longitudinally, stretching it out.
- Applⁿ - Creating long parts like rods, shafts & tapered.
 - E - lengthening a short metal rod into a thinner and longer wire.

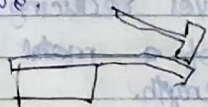


3) Cutting :-

- D - Cutting is the process of separating or trimming parts of the workpiece using a chisel, shear and other cutting tools.
- H - The workpiece is heated and struck to cut off excess metal or to divide it into smaller sections.
- A - Used to remove flash (excess material) from forged parts or prepare a billet for further forging.
- Ex - Cutting a metal bar into smaller pieces for subsequent shaping.

4) Bending :-

- Definition - Bending involves changing the shape of a metal workpiece by creating an angle or curve.
- H - The metal is heated and placed over a die or mandrel, then pressed or hammered to achieve the desired bend.
- A - Used in creating hooks, clamps or bent components for structural or industrial purposes.
- Ex - Bending a flat metal strip into a "U" or "L" shape.

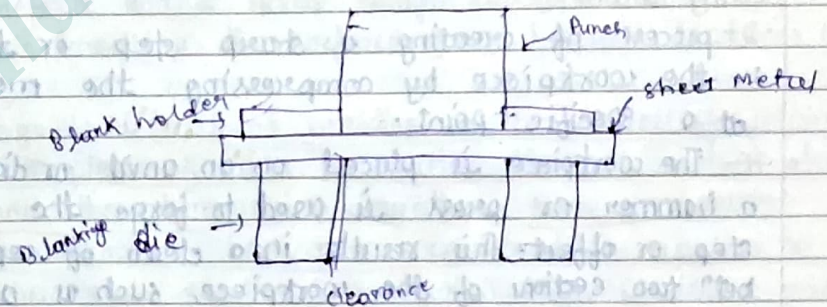


* Punching :-

- process of creating a hole in a heated workpiece using a punch tool.

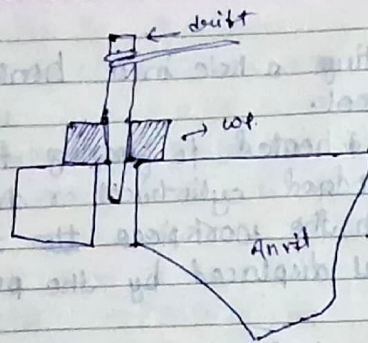
H - The metal is heated to forging tempⁿ, and a punch (a sharp-edged cylindrical or shaped tool) is driven through the workpiece to form a hole. The material displaced by the punch flows around it.

A - used for making holes in components like flanges, gears or handles.



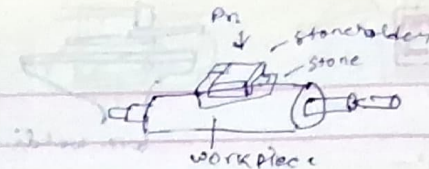
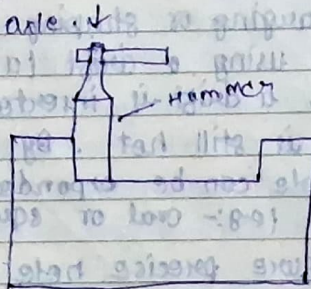
* Drifting :-

- D - process of enlarging or shaping an existing hole in the workpiece using a drift (a tapered tool).
- H - After punching, a drift is inserted into the hole while the metal is still hot. By driving the drift through, the hole can be expanded or shaped into specific form (e.g. - oval or square).
- A - used to ensure precise hole dim. or modify hole shape.



* Setting die:-

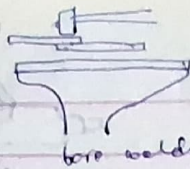
- D- process of creating a sharp step or transition in the workpiece by compressing the metal at a specific point.
- H- The workpiece is placed on an anvil or die and a hammer or press is used to forge the desired step or effect. This results in a clean of separation betⁿ two sections of the workpiece, such as a shoulder or a flange.
- A- used in making stepped shafts, collars or shoulders in components.
- E- creating the base shoulder for a bolt or



* Finishing:-

- D- It is the final stage of forging, where the workpiece is refined to its exact dim. and surface quality.
- H- The nearly completed workpiece is subjected to light hammering or pressing to remove surface irregularities, ensure precise shape and improve the surface finish. It often involves using a die to achieve uniformity.
- A- Ensures the final product is smooth, free of defects and meets design specifications.
- Ex- Smoothing the surface of a forged blade or tool.

- * Forge welding:- Forge welding is the process of joining two pieces of metal by heating them to a high temp and then hammering together. Now, a repeated hammering or high pressure load is applied on these plates together. Due to this high pressure and tempⁿ, inter-molecular diffusion takes place at the interface surface of the plate which makes a strong weld joint. One of the basic requirements of this type of welding is clean interface surface which should be free from oxide or other contaminants. To prevent the welding surface from oxidation, flux is used which mixes with the oxide and lowers down its melting tempⁿ and viscosity. This allows to flow out the oxide layer during heating and hammering process.



bore welding

Working:-

> First both the work plates heated together. The heating tempⁿ is about 50 to 90% of its melting tempⁿ. Both the plates are coated with flux.

> Now manual hammering is done by a blacksmith hammer for making a joint. This process is repeated until a proper joint is created.

> For welding large work piece, mech. hammering is used which is either driven by electric motor or by using hydraulic means. Sometimes dies are used which provide finished surface.

Applications:-

- > used to join steel or iron.
- > used to manufacture gates, piston cells etc.
- > widely used in warfare.
- > used to weld weapon like sword etc.
- > used to weld shotgun barrels.

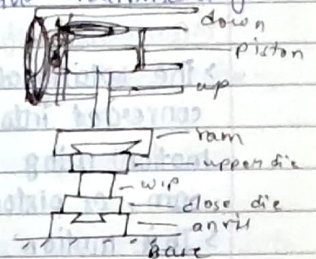
Advantages

- simple and easy.
- It does not require any costly equipment for weld small piece.
- It can weld both similar and dissimilar metals.
- No filler material required.



Disadvantages:-

- > Only small objects can be weld.
- > Larger objects required large press and heating furnaces, which are not economical.
- > It is a slow welding process.
- > Mostly suitable for Fe and steel.
- > It cannot use in mass production.
- > High skill required because excessive hammering can damage the welding plate.
- > High welding defects involve.

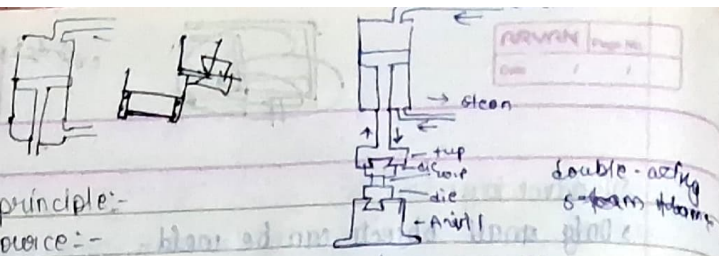


1) Estimation

- 2) Explain the working principle of power hammer
- 3) Components produced by power forging:-

2) Power Hammer:- It is a mechanical forging device that uses mech. pneumatic or hydraulic energy to drive a mechanism that raises and lowers the hammer (ram). By converting rotational energy into reciprocating motion to deliver repeated hammering blows on a workpiece. It is a machine used for shaping, forging and deforming metal. The force of these blows deforms the metal into the desired shape. This machine is much faster and more powerful than a hand hammer, making it ideal for industrial work.

- faster than hand forg.
- large & complex operation



Working principle:-

1) Power source:-

- > A power hammer gets energy from a source such as an electric motor, compressed air (pneumatic), steam or hydraulic pressure.
- > This energy is used to operate the hammer's main parts and create movement.

2) Conversion of motion:-

- > The rotational energy from the power source is converted into up-and-down motion (reciprocating motion) using a mechanism like crankshaft, eccentric cam, or piston.
- > This motion raises and lowers the ram (the hammer head).

3) Lifting the Ram:-

- > In the driving mechanism first lifts the hammer head upward, storing energy.

For example:-

- In mech. hammer, the crankshaft rotates, pulling the ram upward.

- In pneumatic hammer, compressed air pushes the ram up.

4) Hammering action:-

Once the hammer head is raised, it comes down quickly under force. The downward force comes from gravity, mech. force, pneumatic or hydraulic pressure.

5) Impact on workpiece:-

- > The hammerhead strikes the workpiece placed on the anvil.
- > The force of the blow causes the metal to deform and take the desired shape.
- > Repeated blows allow precise shaping and forging of the material.

Key components of a power Hammer:-

- 1) Power source:- provides (electric motor, steam air or hydraulics)
- 2) Frame:- The rigid structure that supports the entire hammer assembly.
- 3) Driving mechanism:- converts rotational motion into reciprocating motion.
- 4) Ram (Hammerhead):- the moving part that strikes the workpiece.
- 5) Anvil:- The strong, stable base where the workpiece is placed.
- 6) Flywheel:- stores energy and ensures smooth operation.

Types of power hammer:-

1) Mech. power Hammer:-

- > uses a crankshaft or eccentric cam connected to a flywheel driven by an electric motor.
- > the rotational energy is converted into vertical reciprocating motion, moving the hammer up and down to strike the workpiece.

2) Pneumatic power hammer: use compressed air for the hammering action.

3) Hydraulic power hammer: uses the hydraulic pressure to drive the hammer.

Applications:-

i) Forging: creating strong, durable metal parts cutting,

ii) Shaping: bending and forming metal sheets.

iii) Riveting: joining metal components by riveting, welding and other methods.

iv) Embossing: Adding designs to metal surfaces.

Advantages:-

1) Faster and more efficient than manual hammering.

2) produces precise and uniform shapes.

3) Handles heavy and large workpieces.

4) Reduces manual labor and increases productivity.

Here the components produced by power forging:-
Power forging is used to produce a variety of components, especially those that require high strength, durability and precise shaping. The following comp. are commonly produced using power forging.

1) Automotive Comp.:-

> crankshafts > connecting rod > Gears

> wheel hubs > camshafts

2) Aerospace comp.:-

> Turbine blades

> Aircraft landing gear comp.

> Engine comp. (shafts, discs and rings).

3) Industrial Equipment:-

> Turbine blades Hammer heads

> Aircraft landing gear comp. wrenches

> Engine comp. (shafts) Green blanks

> coupling

> valves of flanges

4) Railway comp.:-

> Railway wheels

> Axles

> coupling rods

> Bearing housings

5) Agricultural Machinery comp.:-

> Plowshares

> Harrow discs

> Tractor comp.

6) Agricultural Defense and military comp.

> Gun barrels

> Missile comp.

> Armored vehicle parts

7) Tools and Hardware

> Hammers

> spanners and wrenches

> chisels

> pliers

8) Marine comp.

> propeller shafts

> Ship engine comp.

② Explain forging losses- forging Defects

* **Forging Losses**:- refers to the material or energy losses that occur during the forging process. These losses can happen due to various reasons, such as process inefficiencies, design limitations or unavoidable wastage. These losses can affect the overall cost, final output and quality of the forged product.

Types of forging losses:-

1) Flash Losses:-

- It is the excess material that is squeezed out of the die cavity during closed-die or impression die forging.
- This happens because the die is intentionally designed with extra material to ensure complete filling.
- The flash is trimmed off later, which leads to material loss.

2) Scale Losses:-

- During hot forging, the metal is heated to high temp.
- The surface of the heated metal reacts with oxygen in the air, forming oxide scales.
- These scales are brittle and break off during forging, leading to material loss.

3) **Trimming Losses**:- After forging, excess materials like flash and other unwanted parts must be trimmed or cut off.

4) Sprue and Runner Losses:-

- In processes like - die casting or automatic forging metal flows through sprues or runners to reach the die cavity.
- The material left in the sprues and runners after forging leads to waste.

5) Heating Losses:-

- Inefficient use of energy in heating furnace or pressure due to poor thermal insulation, excessive heating or energy losses.

6) **Time Losses**:- Downtime due to die preparation, maintenance or equipment failure. Excessive set-up time or slow production cycles.

7) Rejection or Defective Losses:-

- Poorly forged comp. due to improper forging techniques, defects (like - cracks, underfills or misalignment) or poor-quality material - leads to rejected parts. Such parts contribute to both material and energy losses.

* **Forging Defects**:- They are imperfections or irregularities that occur in forged comp. due to improper process parameters, material issues or equipment limitation. These defects affect the strength, performance and quality of the final product.

Common forging defects and their remedies:-

1) **Laps**: These are folds in the metal that form when the surface fails to close properly during forging.

- **Remedy**: Ensure proper die design and alignment.
- **Control**: the temp and the force used to close the die.

2) **Cracks**: Cracks can occur due to excessive strain or improper cooling.

- **Remedy**: Use the right forging temp and ensure even cooling. Avoid overworking the metal by metal by applying proper strain rate.



3) **Cold shut**: This occurs when the metal does not properly fuse at the point of contact, forming a weak spot.

- **Remedy**: Use proper die design to eliminate improper flow paths. Ensure the correct temp for forging.

4) **Inclusions**: Foreign particles (e.g., slag, dirt, or oxides) trapped in the metal can cause inclusions.

- **Remedy**: Proper cleaning of material before forging along with improved material quality control and furnace practices.

5) **Misalignment**: When the dies are not aligned properly, it leads to uneven forging or distortion.

- **Remedy**: Maintain proper die alignment and regular maintenance of the forging press or hammer.

6) **Overheating**: can lead to grain growth or oxidation on the surface of the material.

- **Remedy**: Control temp and avoid overheating, ensuring the metal is within the optimal range for forging.

7) **Underfilling**: Insufficient material flow results in incomplete forging.

- **Remedy**: Increase the material in the die cavity, or adjust forging parameters like pressure or temp.

8) **Flow lines**: These are lines that appear on the surface of the forged part due to improper flow of material.

- **Remedy**: Adjust the die design to encourage better material flow and maintain the correct forging temp.

3) show the youtube videos on comp. produced by forging operations:-
Forging operations produce a variety of comp. that are critical in many industries due to their strength, durability and reliability.

1) Automotive comp.:-

- Crankshafts
- Connecting rods
- Gear blanks
- Axle shafts
- steering knuckles
- wheel hubs
- Transmission comp.

2) Aerospace comp.:-

- Turbine disks
- Engine mounts
- wing brackets
- Landing gear comp.
- Jet engine blades

3) Industrial and machine tool:-

- Gears
- Bearings
- Flanges
- shafts
- Tractor comp.
- Hooks and connectors

4) Agricultural comp.

- Hooks and connectors
- Tractor comp.

5) Defense and military comp.:-

- Artillery shells
- Gun barrels
- Missile comp.

6) Railway comp.:-

- Railcar axles
- wheel blanks
- coupling rods
- Bearing housing

7) Marine comp. (Engine parts)

8) Hand tools and Hardware:-

- Wrenches
- Hammers
- pliers
- Hooks
- Bolts & Nuts

9) Medical Equipment:-

- Surgical instruments
- orthopedic implants (leg-hip joint, knee joint)

CH-08

1) Introduction to sheet metal - show u tube videos on sheet metal operation & applications.

Sheet metal is a type of metal material that is formed into thin, flat sheets. It is a versatile material that can be used in a wide range of applications, including construction, automotive, aerospace, and consumer goods. Sheet metal can be made from various metals, such as steel, Al, Cu and brass. It is one of the fundamental forms used in metalworking, and can be cut and bent into a variety of different shapes.

Properties

1) Thickness: Sheet metal is available in various thicknesses, ranging from 0.01 mm to 10 mm.

2) Material: Sheet metal can be made from various metals, each with its own unique properties.

3) Formability: Sheet metal can be formed into various shapes using different techniques, such as bending, folding and drawing.

4) Strength: High strength-to-weight ratio.

Sheet metal operations:-

Sheet metal operations involve various techniques used to shape, form and assemble sheet metal parts.

- 1) Shearing: Cutting sheet metal into desired shapes and sizes using a shear machine.
- 2) Bending: Forming sheet metal into curved shapes using a bending machine.
- 3) Folding: Forming sheet metal into folded shapes using a folding machine.
- 4) Drawing: Forming sheet metal into ~~fold~~ complex shapes using a drawing machine.
- 5) Punching: Creating holes in sheet metal using a punching machine.
- 6) Welding: Joining sheet metal parts together using welding techniques.

Applications:

- 1) Construction: used in building construction, roofing and cladding.
- 2) Automotive: used in vehicle manufacturing, including body panels, engine comp. and exhaust systems.
- 3) Aerospace: used in aircraft and spacecraft manufacturing, including fuselage, wings and control surfaces.
- 4) Consumer Goods: used in the manufacture of consumer goods, such as appliances, furniture and electronics.
- 5) Medical Equipment: used in the manufacture of medical equipment, such as hospital furniture, medical ~~furniture~~ device and surgical instruments.

- 2) Explain sheet metal materials- standard gauge of sheet - specifications of sheet.

Sheet Metal Materials:

- 1) Carbon steel: A common and economical sheet metal material, carbon steel is suitable for general-purpose.
- 2) Stainless steel: Known for its corrosion resistance and durability, stainless steel is used in food processing, medical equipment and marine appliⁿ.
- 3) Al-A: Lightweight and corrosion-resistant material, Al used in aerospace, automotive and const. applⁿ.
- 4) Cu: An excellent conductor of electricity and heat, Cu is used in elect^r, electronics.
- 5) Brass: A ductile and corrosion-resistant material, used in musical instruments, hardware and decorative fixtures.
- 6) Titanium: Strong and lightweight material, used in ~~medical~~ aerospace, medical and sports equipment.
- 7) Galvanized steel: Corrosion-resistant material, (used in const., auto. and agri. appliⁿ).

Standard Gauge of ^{metal} sheet.

The standard gauge of sheet metal refers to a system that specifies the thickness of sheet metal material in terms of a gauge no. The gauge no. correlates inversely with the thickness i.e. a higher gauge mean high thinner metal. The gauge system is used for metals like steel, aluminium and other materials.

Common Gauge standards:-

1) United States standard gauge:-

> used primarily for ferrous (iron-based) metals like carbon steel and stainless steel.

> Thickness is measured in inches or millimeters.

eg:- steel 16 gauge $\approx 1.50\text{ mm}$ (0.063 inches)

Al 15 gauge $\approx 1.20\text{ mm}$ (0.051 inches)

2) Birmingham Gauge (BG):-

- often used for non-ferrous metals like Al, Cu & brass and wires.

3) Metric Systems:-

- Directly specifies thickness in millimeters (eg. 0.5mm, 1mm).

4) Standard Wire Gauge (SWG):-

Used mainly in the UK for non-ferrous metals.

Specification of sheet:

→ A specification of a sheet typically refers to the technical details or characteristics that define a particular sheet material. This could apply to paper, metal, plastic or other sheet-like materials.

Here are the key aspects that might be included in such a specification.

1) Material type:-

The type of material the sheet is made of.

Such as:-

- Metal (e.g.:- steel, Al, Cu)
- Plastic (e.g.:- PVC, polythene, polycarbonate)
- Paper (e.g.:- bond paper, kraft paper, coated paper)
- Composition material (e.g.:- fibre-reinforced plastic)

2) Dimensions:-

- Thickness: often measured in millimeters, inches, gauge
- Width: The distance across the sheet.
- Length: The distance along the sheet.
- Tolerance: Permissible variation in dimensions.

3) Weight / Density:-

- for paper: GSM (grams per square meter)
- for metal or plastic: Density or weight / unit area

4) Surface finish:-

- Smooth, matte, glossy, textured, brushed or polished.
- Coatings (e.g.:- galvanized, painted, laminated), plating.

5) Mechanical properties:-

- Strength: Tensile strength, yield strength
- Hardness: measured in terms of brinell, vickers or mohs scale.
- Flexibility or bending tolerance and ductility.

6) Thermal & electrical properties:

- Thermal conductivity or resistance
- Electrical " " or Insulation

7) Chemical properties:-

- Resistance to corrosion, UV-radiation or chemical.
- composition or alloying elements (for metals).

8) standard & application:-

- compliance with industry standards such as
(i) ISO (ii) ASTM (iii) EN standards.

9) Usage specifications:-

- Intended applications, such as roofing, packaging, decoration, insulation etc.

10) Sheet size :- standard size:-

- ↳ 4 ft x 8 ft (1219 mm x 2438 mm), 5 ft x 8 ft
(1524 x 3048 mm)

↳ Custom dim. are also available.

—: CH-11 :—

② Introduction to power press - power size press - ^{tools} size press die Accessories.

Introduction to power press

A power press is a machine used to shape or cut materials, commonly in metalworking using mechanical, hydraulic, or pneumatic power. It's used for high-speed like punching, stamping, bending and embossing and is essential in industries such as automotive and metal fabrication.

Press size

- Capacity: refers to the max... tonnage (force) a press can exert, ranging from small to large industrial presses.
- Bed size: The area where the mate... is placed, defines the size of parts that can be processed.
- Stroke length: the dist... the ram moves during a cycle, affecting the depth of work.
- Sheet height: The gap betⁿ the ram and die when fully up, determining mate... thickness.

Press Tools

Press tools perform various operations like:

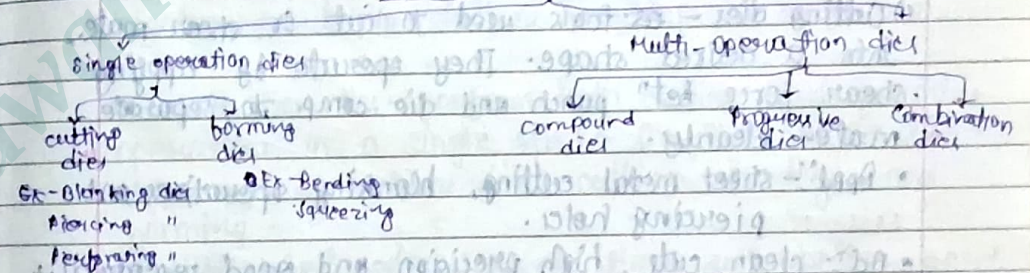
- Punching Tools - cut holes in materials
- Stamping " - shape or emboss patterns
- Bending " - Bend or shape metal
- Cutting " - Cut mate... to specific shapes or sizes.

Die Accessories

- These are comp. that support press tools, improving precision and tool life:
- Die sets: Hold the press tools in place.
 - Die springs: Apply pr. and help return the die after each cycle.
 - Guide pins and bushings: Ensure alignment betⁿ die parts.
 - Strippers: Eject parts after pressing.

3) Types of die and its operations

Dies used in press working



Dies are tools used in a power press to shape, cut, or form materials like metal, plastic or rubber.

Single Operation die

- Performs one operation (ex- punching, blanking, cutting).
- simple design and easy setup.
- cost-effective for low-vol. or simple tasks.
- faster setup time and easier maintenance.
- limited for complex or multi-step operations
- best for small batches or simple parts.

Multi-operation die.

- perform multiple operations (e.g. punching, blanking, bending) in a single cycle.
- Complex design with multiple stages.
- Higher initial cost, but more cost-effective for high-vol. production.
- longer setup time due to complexity.
- Ideal for mass production and high-vol. manufacturing.
- reduces labor and handling during production.

Types of dies

1) Cutting dies - tools used to cut or shear material into a desired shape. They operate by applying shear force between punch and die comp. to separate material cleanly.

- Appl: sheet metal cutting, blanking operations and piercing holes.
- Adv: clean cuts, high precision and good repeatability.

2) Forming dies - shape material without cutting or removing any material. They create three-dimensional shapes through bending, drawing, or other deformation processes.

- Appl: Bending, drawing, embossing, and coining operations.
- Key features: Multiple stages may be required for complex shapes.

3) Compound dies - perform multiple cutting operations in a single press stroke. They combine various cutting operations like blanking and piercing

simultaneously.

- Benefits: Higher productivity and better dim. acc.
- Usage: when multiple cutting operation need to be performed on the same part.

4) Progressive die - perform a series of operations on a strip of material as it moves through different stations. Each station performs a specific operation, building upon previous operations.

- Adv: High production rates and automation capability.
- Appl: Mass production of complex parts.
- Features: Multiple stations working in sequence.

5) Combination dies - perform both cutting and forming operations in a single stroke. They combine different types of operations like cutting, bending, and forming.

- Benefits: Reduced handling time and better part consistency.
- Appl: Parts requiring both cutting and forming operations.
- Prop: Complex design but efficient production.

CF-12

1) Introduction ~~of~~ to rolling - Nomenclature of rolled products - dies used in rolling process

2) Types of rolling mills - High mill - 8 High mill - 4 high mill - Cluster mill, Tandem mill, Planetary mill, defects in rolling.

3) Intro to extrusion and drawing - Types of extrusion process. Wire and Tube drawing process, dies used in Extrusion and drawing process.

Intro

1) Rolling is a metal working process that involves the deformation of metal by passing it through a pair of rolls. Rolling can be performed at diffⁿ temp^s, leading to various techniques and appl^s.

Key components

- Work rolls: direct contact with the material.
- Backup rolls: support work rolls and prevent deflection.
- Roll stands: house the rolling mechanism.

Appl^s:

- Production of metal sheets and plates.
- manufacturing of structural shapes.
- creation of rails and beams.

Nomenclature of rolled products

1) Types of R.P

- Hot rolled products - includes hot rolled sheets, plates, bars.

- Cold A.P - includes cold rolled sheets and strips.
- rolled sections - structural shapes like I-beams, channels and Ls.

2) Nom... Comp. :-

- Material type, thickness, width, length, grade, finish

3) Common designations:

- ASIM standards: specifications for material properties and testing.
- EN standards: European classification for rolled products.

4) Ex:

- Hot rolled steel plate: HRP 10mm x 2000mm x 4000mm
- Cold " " sheet: CRS 15mm x 1000mm x 2000mm
- structural I-beam: S 10 x 20 x 3/8 (depth, weight / foot, flange thickness).

dies used in rolling process - are essential tools that shape and form metal into desired profiles and dimensions.

1) Flat dies

Description - produce flat products like sheets and plates.
operation - Metal is compressed betⁿ two flat surfaces.

Appl^s - Used in hot and cold rolling mills.

2) Shape dies

- create specific cross-sectional shapes (I-beams, channels)
- metal is shaped through contoured dies.
- A - structural steel production.

3) Ring dies:

- D - cylindrical shapes like pipes and tubes.
- O - Metal is rolled into a circular shape.
- Appl: for seamless pipes and tubes.

4) Roller dies:

- D - use multiple to shape metal.
- O - Rollers apply pr. to gradually form the metal.
- A - Ring rolling and production of bars and rods.

5) Profile dies:

- D - Create complex profiles with specific geometric features.
- O - Metal is shaped through a specially contoured die.
- A - Decorative metal work and specialized comp.

Types of rolling Mills

Rolling mills are industrial machines used to shape and form metal by passing it through rollers.

1) 2-High Mill

- D - Consists of two horizontal rolls, one above the other.
- O - The metal is fed betⁿ the two rolls, which apply pr. to reduce its thickness.
- A - used for hot and cold rolling of sheets, plates and bars.

2) 3-High mill

- D - Features three rolls arranged vertically, with one roll in the middle and two rolls on the top and bottom.

- O - The metal passes through the top and middle rolls, then returns through the middle and bottom rolls, allowing for multiple passes without reversing the metal.
- A - for rolling thicker metal and in applⁿ where the metal needs to be processed multiple times.

3) 4-High mill

- D - Contains four rolls: two larger rolls (back up rolls) and two smaller rolls (work rolls).
- O - The smaller work rolls reduce the thickness of the metal, which the larger back-up rolls provide support to prevent deflection.
- A - thin sheets and foils, used in cold rolling processes.

4) Cluster mill

- D - A type of 4-high mill with multiple rolls (usually 6 or more) arranged in a cluster.
- O - The design allows for very thin sheets to be rolled with minimal force, as the smaller rolls are supported by larger back-up rolls.
- A - for rolling very thin metal, such as foils and thin sheets.

5) Tandem Mill

- D - Comprises a series of two or more rolling stands arranged in sequence.
- O - The metal is passed through multiple stands in a continuous process, allowing for significant

reductions in thickness in a single pass.

- A - used in the production of sheets and strips, particularly in high-vel. operations.

6) Planetary mill

- D - features a set of planetary rollers that rotate around a central axis while also rotating on their own axes.
- O - This unique motion allows for complex shapes and profiles to be formed with high precision.
- A - for specialized appl^s, including the production of complex profiles and shapes in metalworking.

Defects in rolling

1) Surface defects:

- scratches: Marks caused by foreign particles or improper handling.
- scale: Oxidation on hot-rolled steel affecting surface quality.
- pits and voids: small holes due to inclusions or gas entrapment.

2) dim. defects:

- Thickness Variation: Inconsistent thickness across the product.
- width Variation: changes in width due to misalignment or wear.
- length Variation: Inconsistency in length from improper cutting.

3) Geometric defects:

- Camber: Curvature along the length of the product.
- Twist: spiral deformation caused by uneven rolling.
- Bowing: Curvature across the width due to uneven cooling.

4) Internal defects:

- Cracks: internal or surface cracks from excessive stress.
- Inclusions: Non-metallic particles trapped within the metal.
- Porosity: Voids caused by gas entrapment during rolling.

5) Mechanical defects:

- Lamination: separation of layers within the rolled products.
- Hard spots: Areas of increased hardness leading to uneven wear.

Introduction to extrusion and drawing are two imp. metal forming processes used to create products with specific shapes and dim. Both processes involve the deformation of materials, typically metals or plastics, to produce long, continuous shapes or profiles.

* Extrusion - A process where mate. is forced through a die to create continuous shape with a fixed cross-section.

Process - raw mate. is often heated, is pushed through a die using a ram or screw, taking the shape of the die as it exits.

Types

- 1) Hot ex. - Performed at elevated tempⁿ for easier deformation.
- 2) Cold ex. - Conducted at room tempⁿ for higher strength.
- 3) Direct and Indirect ex. - differ in mate. flow relative to the ram.

Applⁿ

Used for producing Al and plastic profiles, pipes, tubes and structural comp.

* Drawing - process that involves pulling mate. through a die to reduce its dia. and increase its length.

Process - Mate. is drawn through a die by applying a pulling force, elongating it and reducing its cross-section.

Types

- > Wire drawing: produce wire by reducing rod dia.
- > Bar " : produce longer bars with

reduced cross-section.

> Tube drawing: draws hollow tubes to specific dim.

Applⁿ - used for wires, cables and precision metal comp.

Types of extrusion process

- 1) Hot extrusion - The mate. is heated above its recrystallization tempⁿ before being extruded.
Ad -
 - Easier deformation of the mate.
 - Improved flow characteristics.
 - reduced energy requirements.

Applⁿ: used for metals like Al, Cu, and steel to produce profiles, rods and tubes.

- 2) Cold extrusion - mate. is extruded at or near room tempⁿ.

Ad -

- Higher strength and better surface finish due to work hardening.
- no need for heating, which saves energy.

Applⁿ: used for producing small parts, fasteners and comp. where dim. acc. is critical.

- 3) Warm extrusion: - mate. is heated to a tempⁿ betⁿ room tempⁿ

and its recrystallization temp?

Adv:-

- Balances the benefits of hot and cold extrusion.
- reduces the risk of cracking while improving flow.

Appⁿ:- Used for metals that are difficult to extrude at room temp.

- 4) Direct extrusion - metal is pushed through the die in the same direction as the ram movement.

Adv:- simpler setup and lower tooling costs.

Appⁿ:- producing profiles and shapes.

- 5) Indirect Extrusion:- The die moves towards the metal, which is pushed in the opposite direction.

Adv:- reduces friction betⁿ the metal and the container.

- Allows for better control of the extrusion process.

Appⁿ:- Used for producing hollow sections and complex shapes.

Wire and Tube drawing process - used to reduce the dia. and increase the length of metal rods or tubes by pulling them through a die, producing wires, cables, and tubes with precise dim.

Wire drawing process

- wire drawing is the process of reducing the dia. of a metal rod or wire by pulling it through a series of dies.

Process

- Preparation: The starting metal, usually a metal rod, is cleaned and sometimes preheated.

- Drawing: The rod is pulled through a die which has a smaller dia. than the rod. This reduces the rod's dia. and elongates it.

- Multiple passes: The drawing process often involves multiple passes through progressively smaller dies to achieve the desired dia.

- Annealing: After several passes, the wire may be annealed (heated and cooled) to relieve internal stresses and improve ductility.

Types

- Single die drawing: involves one die for each pass.

- Multi " " " - Uses multiple dies in a

single setup to reduce the dia. in one continuous operation.

Applⁿ: produce elect. wires, cables and various metal comp. requiring precise dim. and high strength.

Tube drawing process - of reducing the dia. and increasing the length of a hollow tube by pulling it through a die.

Process

- ~~Pre~~ c - The starting tube is cleaned and may be preheated.

- d - The tube is pulled through a die, which reduces its outer dia. while increasing its length. The process can also involve a mandrel to maintain the inner dia.

- m.p - similar to wire drawing.

- An - The tube may be annealed after drawing to relieve stresses and improve ductility.

Types

- Conventional T.d - involves drawing the tube through a die without a mandrel.

- Mandrel drawing - use a mandrel inside the tube to control the inner dia. while reducing the outer dia.

Applⁿ: used in the production of hydraulic tubes, st. tubing and various hollow comp. in aero and auto industries.

Dies in extrusion

- Flat die - produce flat products like sheets and plates.

- Profile die - create specific cross-section shapes (e.g. channels, Ls)

- Pipe and tube die - used for hollow sec., often with a mandrel to maintain inner dia.

- Continuous ex. die - Allow for the production of long lengths of mate.

Mate - made from high-strength tool steel or carbide to withstand high pr. and tempⁿ.

Dies in drawing

- wire d.d - tapered die that reduce the dia. of wire.

- Tube d.d - designed for hollow tubes, may include a mandrel for inner dia. control.

- Multi-die system - use multiple dies in seq. for significant dia. reductions.

Mate - same as made from hardened tool steel or carbide for durability and wear resistance.

Crank shaft, valves, wheel, Gear axle, Flywheel, spring.

1) Crank shaft - is a key comp. in an internal combustion engine. It converts the linear motion of the pistons into rotational motion, which ultimately drives the vehicle's wheels. The crankshaft is connected to the pistons through connecting rods. As the pistons move up and down, the crankshaft turns, powering the engine. Crankshafts are usually made of ^{made by casting, forging} steel or forged iron to withstand the high stress and forces involved.

2) Valves - ^{most commonly used valve-type valve (rotation valve)} are comp. used in engines to control the flow of air and fuel into the engine's cylinders and the exhaust gases out. There are typically two main types of valves in an engine:

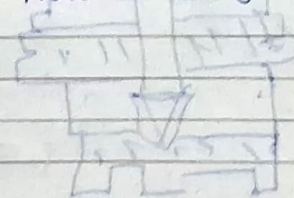
- Intake valves - These open to allow the air-fuel mixture into the combustion chamber.
- Exhaust valves - These open to let out the exhaust gases after combu. Valves are operated by the crankshaft, and they are critical for proper engine timing, efficiency and performance.

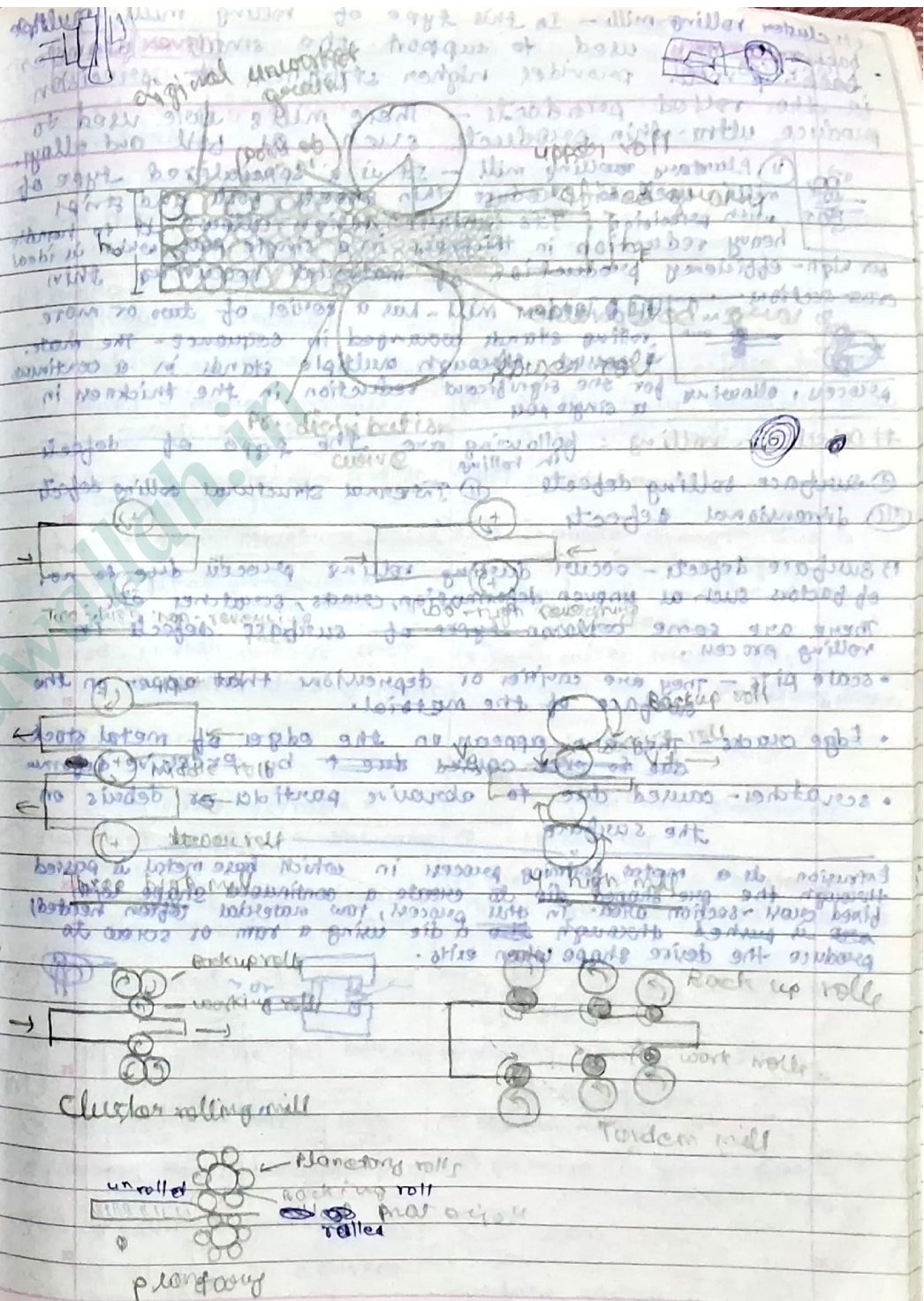
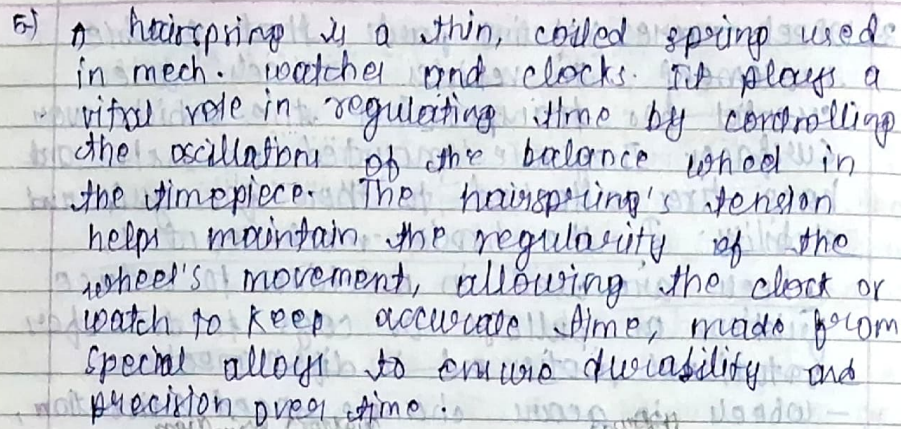
Ex - Gate v. Globe v. Ball ^(Jaw ball) NPV Valve (check v) ^(one direction) P S V ^(no handle) & PRV valve

3) Wheels - are rotating parts that enable movement. In vehicles, wheels are essential for transporting the vehicle over surfaces. They are mounted on axles and have tires attached to them for grip and stability. In the broader mech. context, wheels are used in machines to reduce friction, as pulleys or cogs to transfer rotational motion and in diff'n motion.

- wheels in gear change speed/direction, reduce friction in systems like conveyors, help lift heavy loads, maintain smooth engine rotation, multiply force for easier movement

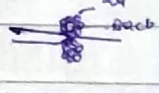
4) Gear axle - or gearbox is a housing that contains gears and is used to transmit power betⁿ diffⁿ parts of a m/c. It adjusts the speed, torque, or dir. of rotational motion. Gearboxes are commonly found in vehicles, machinery, and engines, where they help control how power is delivered to the wheels or other moving parts. Gearboxes can be manual or automatic, depending on how the gears are changed.





(i) cluster rolling mills - In this type of rolling mills, multiple backrolls are used to support the small diameter back-up rolls. provides higher stiffness & precision in the rolled products - These mills were used to produce ultra-thin products such as foil and alloy.

(ii) Planetary rolling mill - It is a specialized type of mills used to produce thin sheets, coils and strips with precision. Its unique design allows it to handle heavy reduction in thickness in a single pass, which is ideal for high-efficiency production of material requiring thin cross sections.



(iii) Tandem mill - has a series of two or more rolling stands arranged in sequence. The mate. is passed through multiple stands in a continuous process, allowing for the significant reduction in the thickness in a single pass.

Defects in rolling: following are the type of defects in rolling

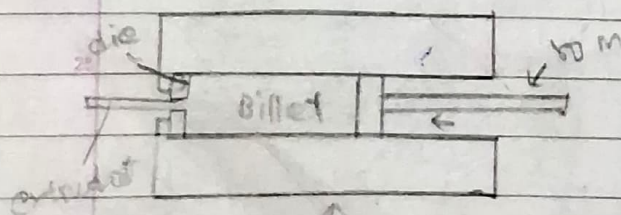
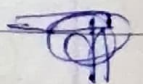
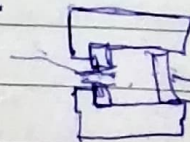
- (i) Surface rolling defects
- (ii) Internal structural rolling defects
- (iii) Dimensional defects

1) Surface defects - occur during rolling process due to no. of factors such as uneven deformation, cracks, scratches etc.

There are some common types of surface defects in rolling process.

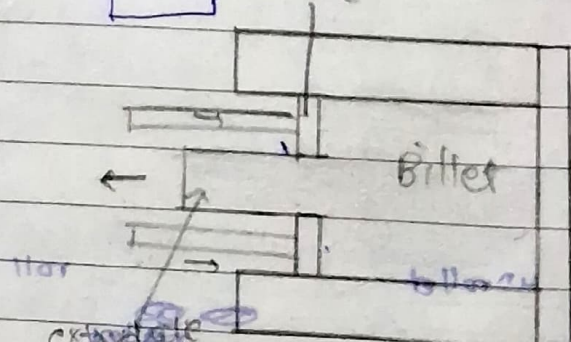
- scale pits - They are cavities or depressions that appear on the surface of the material.
- Edge cracks - They appear on the edges of metal stock due to ~~excess~~ ~~caused~~ ~~due to~~ by excessive deformation.
- scratches - caused due to abrasive particles or debris on the surface.

Extrusion is a metal forming process in which base metal is passed through the pre-shaped die to create a continuous shape with fixed cross-section area. In this process, raw material (often heated) ~~is~~ is pushed through ~~the~~ a die using a ram or screw to produce the desired shape when exits.



↑
container

direct
extrusion



↑
container

Hot extrusion

- i) Above recrystallization tempⁿ (heated)
- ii) produces softer, weaker material
- iii) lower force required
- iv) can create complex and large shapes.
- v) energy consumption is high (due to heating)
- vi) can have rougher surface
- vii) Applⁿ - large profiles, soft metals (Al, Cu)
- viii) common materials - Al, Cu and steel.
- ix) improve grain structure, uniformity
- x) Al - Ideal for complex & large shapes
- xi) draw - higher energy cost, oxidation during process
- xii) dim. acc. - low

Cold extrusion

- i) Below (room temp)
- ii) stronger, tougher material (work hardening)
- iii) higher
- iv) more suited for smaller, simpler parts
- v) low
- vi) smoother surface finish
- vii) Applⁿ - small, precision parts (automotive parts, bolts)
- viii) brass, Cu, Al
- ix) Increase strength due to work hardening
- x) produces precise and strong parts
- xi) Requires more force, limited to smaller shapes
- xii) dim. acc. - high

Direct extrusion

- i) Material flows in the same direction as the ram.
- ii) ram pushes the material directly forward to the die.
- iii) die located at the end of billet
- iv) higher friction betⁿ matⁿ & die
- v) faster
- vi) less smooth due to high fric
- vii) larger cross-sect. shapes & profiles (Al, Cu)
- viii) requires more energy
- ix) higher wear on equipment
- x) poor
- xi) cost-effective for large profiles

Indirect extrusion

- i) opposite dir.
- ii) ram pushes the material backward, opposite to the die.
- iii) die is fixed at the opp. of the billet
- iv) lower friction
- v) slower
- vi) smoother
- vii) precise or small parts (rods & tubing)
- viii) less
- ix) low
- x) surface finish
- xi) less suited for large parts

die accessories or press acc... are used in conjunction with die and punches for systematic operation, correct location and removal of finished products. 10

① stops - used for correct ^{spacing} location of the sheet metal as it fed to give the max output given the down of the sheet metal.

② Pilot - used for correct location of punch.

③ Shippers - used for removal of finished products.

④ Knock-out - used for forcing the cut-out blank from the die.

⑤ Die Springs - used for apply pr. and help to return back the die after each cycle.

Sheet metal operations

Bending

classified into two types —

① Cutting

② Forming

(forming)
(shearing)

forming

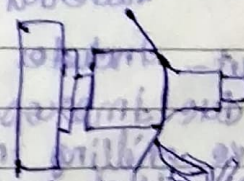
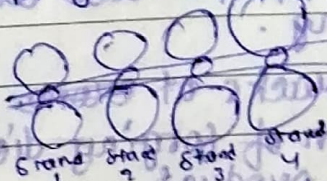
1) Cutting

Bending, roll forming, spinning, deep drawing, stretch forming

2) Cutting - shearing, blanking, piercing, notching, perforating, slitting, lancing

• Bending — metal forming process in which force is applied to the sheet metal causing it to bend at an $\angle$ and form the desired shape. widely used in various industries to shape metal sheets.  plate or roll into specific $\angle$ s.

• Roll forming - continuous bending process used to create long length of sheet metal, often into specific profiles or shapes. This process involves feeding a flat sheet metal through a series of rollers, each progressively shaping the sheet into the desired profile.



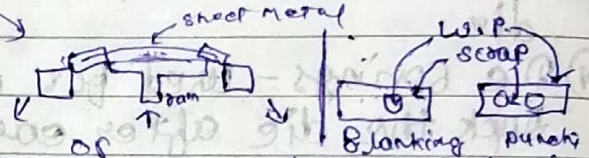
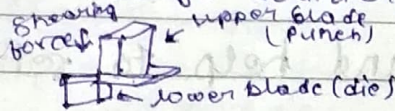
• Spinning - also known as metal spinning, is a manufacturing process used to create circular or

cylindrical shapes. This process involves a rotating disc or tube at high speed while a tool or mandrel shapes the metal into desired form.



- **Deep drawing** - metal forming process that is used to create hollow, seamless shape from a flat sheet metal by using a punch and die. Commonly used to manufacture products such as cans, kitchen sinks, automotive parts and containers. It is a combination of stretching and compressing the material into deep cup like shape.

- **Stretch forming** - metal forming process in which a piece of metal sheet is stretched and bent simultaneously over a die in order to form large contoured parts.



- **Shearing** - m.p which is used to cut or trim the material into specific shape or size by using shear force, typically in the form of sharp, linear cutting edges - commonly used to cut the thin sheets, plates and strips into specific sections or parts.

- **Blanking** - sheet metal forming process used to cut specific shape from large sheet of metal. This process involves a punching a piece of material into desired shape. The punching out material is known as 'blank' and the remaining material referred to as 'scrap' or 'slug'.

- **Punching or piercing** - sheet metal forming process used to create holes, slots or other features in a flat sheet of material by applying a shear force using a punch and die. Similar to blanking, but instead of cutting a separate blank, the punching process removes the part of material to create hole or shape in the sheet.

- **Notching** - sheet metal forming process used to remove notch or indentation from the edge of the sheet metal, typically creating a die and punch. This process is performed by using a

Forging defects refer to the imperfections or irregularities occur in the forged products during forging operations due to improper forging techniques, poor material quality, defective equipment. These defects affect the strength, performance and quality of the final product. Defects

① **Unfilled section**: This type of defect some of the forging section remain unfilled. This is due to poor design of die or poor material or poor heating. This is also occurs due to less raw

Remedies - proper die design, proper raw material & heating.

② **Cold shut** - Includes small cracks at some corners. These defects occurs due improper design of forging die, sharp corner and excessive chilling in forge product.

Remedies - fillet radius of the die should be increased to remove these defects.

③ scale pits:- This defect generally associated with forging in open environment. due to improper cleaning of forged surface.
remedies - by proper cleaning of forged surface.

④ Die shift - caused by misalignment of upper and lower die. when both ~~the~~ these dies are not properly aligned the forged product does not get proper dimension.

remedies - by proper alignment, by provide half notch on upper die and half on lower die so ~~at~~ at the time of alignment, both notches will match.

⑤ Flakes: internal cracks occur due to improper cooling of ^{forged} product when the forged product cooled quickly.

remedies - by proper cooling.

Power forging	Hand forging
1) Use mech. hammer, presser, or hydraulic m/c	1) Manual shaping with hammer and anvil.
2) Fast, suitable for mass production.	2) Slow, labor intensive
3) High acc.	3) No.
4) Strong, uniform grain flow	4) Strong, but vary in grain flow
5) High initial setup cost, cost-effective for large vol.	5) Low setup cost, expensive/labor due to labor.
6) for large-scale prod.	6) Best for small or custom pieces
7) limited flexibility for custom designs.	7) Highly customizable, great for unique items.

is a process of removing metal by feeding