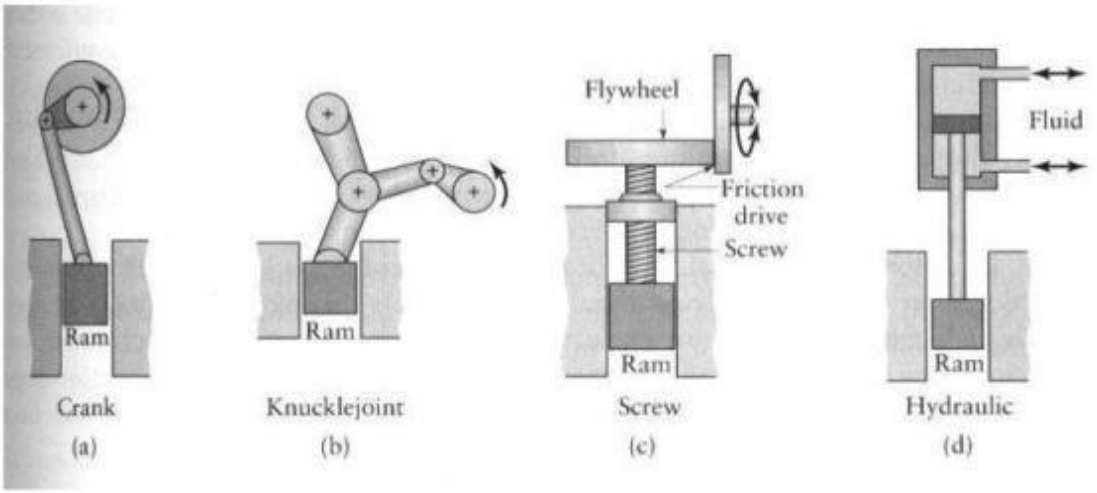
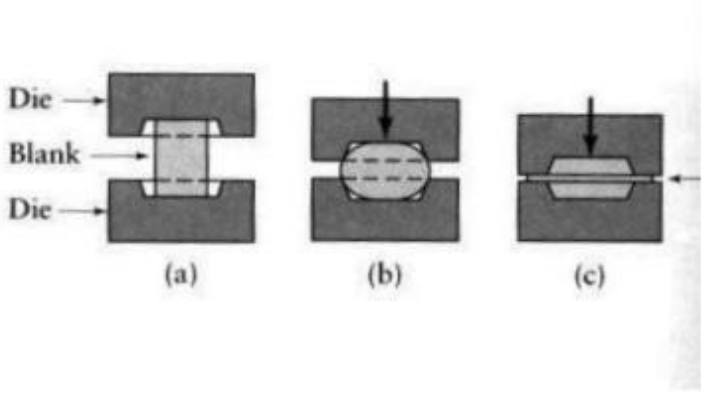
UNIT-IV & V

FORGING,EXTRUSION PROCESS

Types of Forging Presses



Impression Die Forging



Forging operations

Forging is a process in which the workpiece is shaped by compressive forces applied through various dies and tools. It is one of the oldest metalworking operations. Most forgings require a set of dies and a press or a forging hammer.

A Forged metal can result in the following: -

- Decrease in height, increase in section - open die forging
- Increase length, decrease cross-section, called drawing out.
- Decrease length, increase in cross-section on a portion of the length - upsetting
- Change length, change cross-section, by squeezing in closed impression dies - closed die forging. This results in favorable grain flow for strong parts

Types of forging

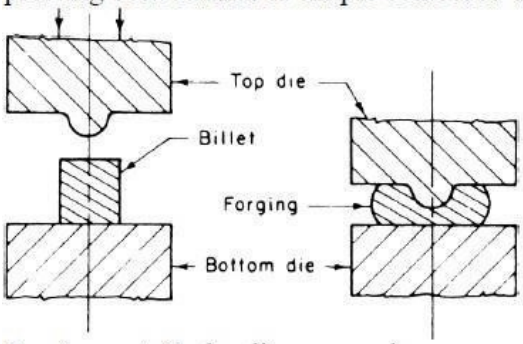
- Closed/impression die forging
- Electro-upsetting
- Forward extrusion
- Backward extrusion
- Radial forging
- Hobbing
- Isothermal forging
- Open-die forgig
- Upsetting
- Nosing
- Coining

Commonly used materials include

- Ferrous materials: low carbon steels
- Nonferrous materials: copper, aluminum and their alloys

Open-Die Forging

Open-die forging is a hot forging process in which metal is shaped by hammering or pressing between flat or simple contoured dies.



Equipment. Hydraulic presses, hammers.

Materials. Carbon and alloy steels, aluminum alloys, copper alloys, titanium alloys, all forgeable materials.

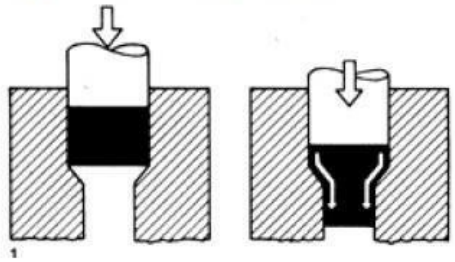
Process Variations. Slab forging, shaft forging, mandrel forging, ring forging, upsetting between flat or curved dies, drawing out.
Application. Forging ingots, large and bulky forgings, preforms for finished forgings.

Closed Die Forging

In this process, a billet is formed (hot) in dies (usually with two halves) such that the flow of metal from the die cavity is restricted. The excess material is extruded through a restrictive narrow gap and appears as flash around the forging at the die parting line.
Equipment. Anvil and counterblow hammers, hydraulic, mechanical, and screw presses.
Materials. Carbon and alloy steels, aluminum alloys, copper alloys, magnesium alloys, beryllium, stainless steels, nickel alloys, titanium and titanium alloys, iron and nickel and cobalt super alloys.
Process Variations. Closed-die forging with lateral flash, closed-die forging with longitudinal flash, closed-die forging without flash.
Application. Production of forgings for automobiles, trucks, tractors, off-highway equipment, aircraft, railroad and mining equipment, general mechanical industry, and energy-related engineering production.

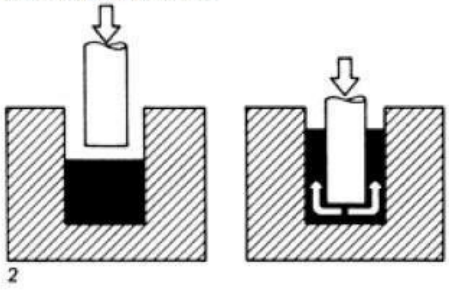
Forward extrusion

Forward extrusion reduces slug diameter and increases its length to produce parts such as stepped shafts and cylinders.



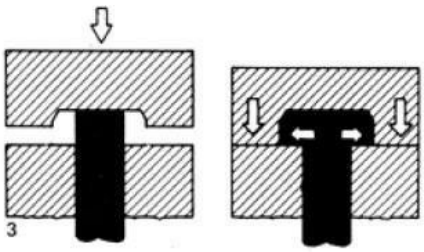
backward extrusion

In backward extrusion, the steel flows back and around the descending punch to form cup-shaped pieces.



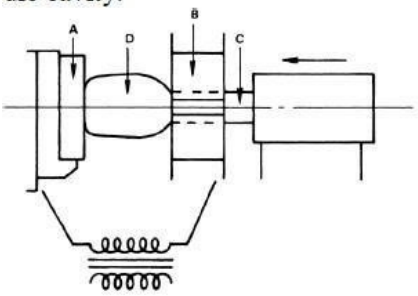
Upsetting, or heading

Upsetting, or heading, a common technique for making fasteners, gathers steel in the head and other sections along the length of the part.



Electro-Upsetting (Fig. 2.4)

Electro-upsetting is the hot forging process of gathering a large amount of material at one end of a round bar by heating the bar end electrically and pushing it against a flat anvil or shaped die cavity.



A, anvil electrode; B, gripping electrode; C, workpiece; D, upset end of workpiece

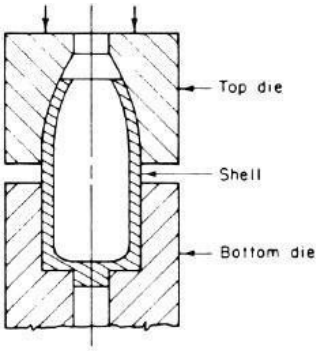
Equipment. Electric upsetters.
Materials. Carbon and alloy steels, titanium.
Application. Preforms for finished forgings.

Hobbing

Hobbing is the process of indenting or coining an impression into a cold orhot die block by pressing with a punch.
Equipment. Hydraulic presses, hammers.
Materials. Carbon and alloy steels.
Process Variations. Die hobbing, die typing.
Application. Manufacture of dies and molds with relatively shallow impressions.

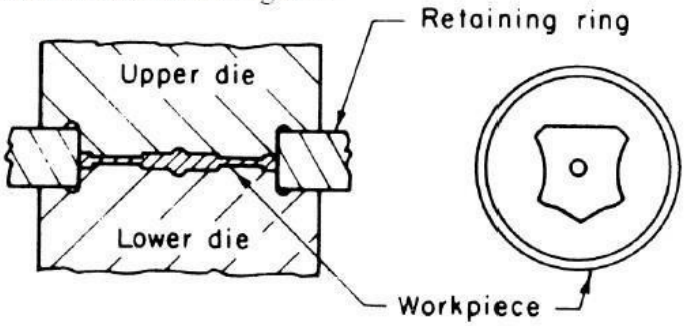
Nosing

Nosing is a hot or cold forging process in which the open end of a shell or tubular component is closed by axial pressing with a shaped die.
Equipment. Mechanical and hydraulic presses, hammers.
Materials. Carbon and alloy steels, aluminum alloys, titanium alloys.
Process Variations. Tube sinking, tube expanding.
Applications. Forging of open ends of ammunition shells; forging of gas pressure containers.



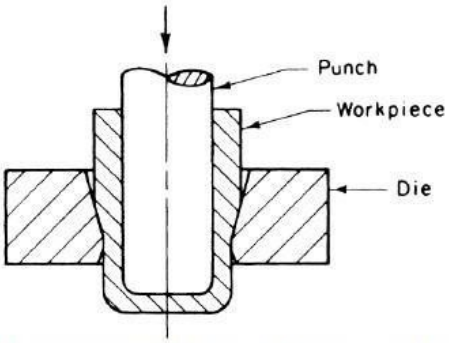
Coining

In sheet metal working, coining is used to form indentations and raised sections in the part. During the process, metal is intentionally thinned or thickened to achieve the required indentations or raised sections. It is widely used for lettering on sheet metal or components such as coins. Bottoming is a type of coining process where bottoming pressure causes reduction in thickness at the bending area.



Ironing

Ironing is the process of smoothing and thinning the wall of a shell or cup (cold or hot) by forcing the shell through a die with a punch.



Equipment. Mechanical presses and hydraulic presses.
Materials. Carbon and alloy steels, aluminum and aluminum alloys, titanium alloys.
Applications. Shells and cups for various

Swaging

Uses hammering dies to decrease the diameter of the part

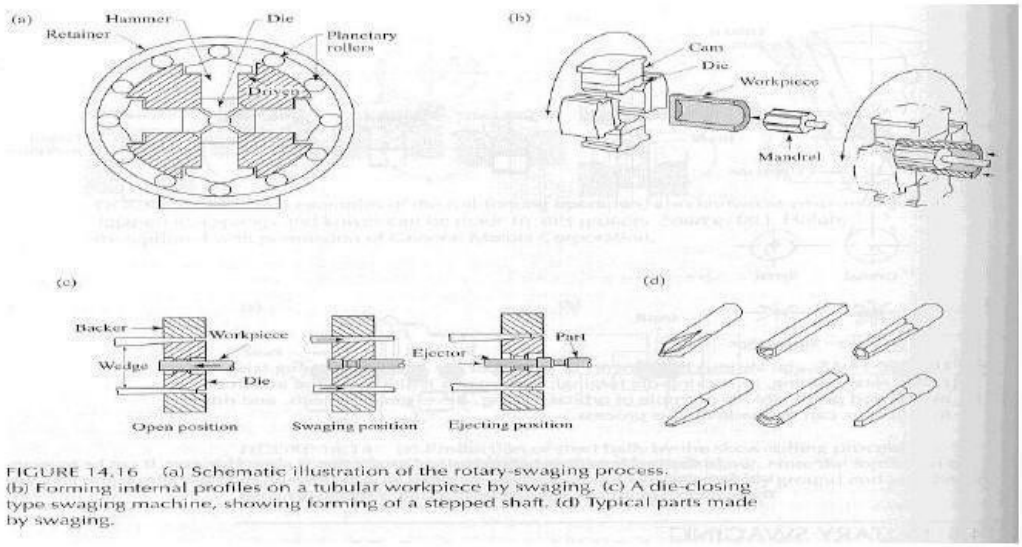
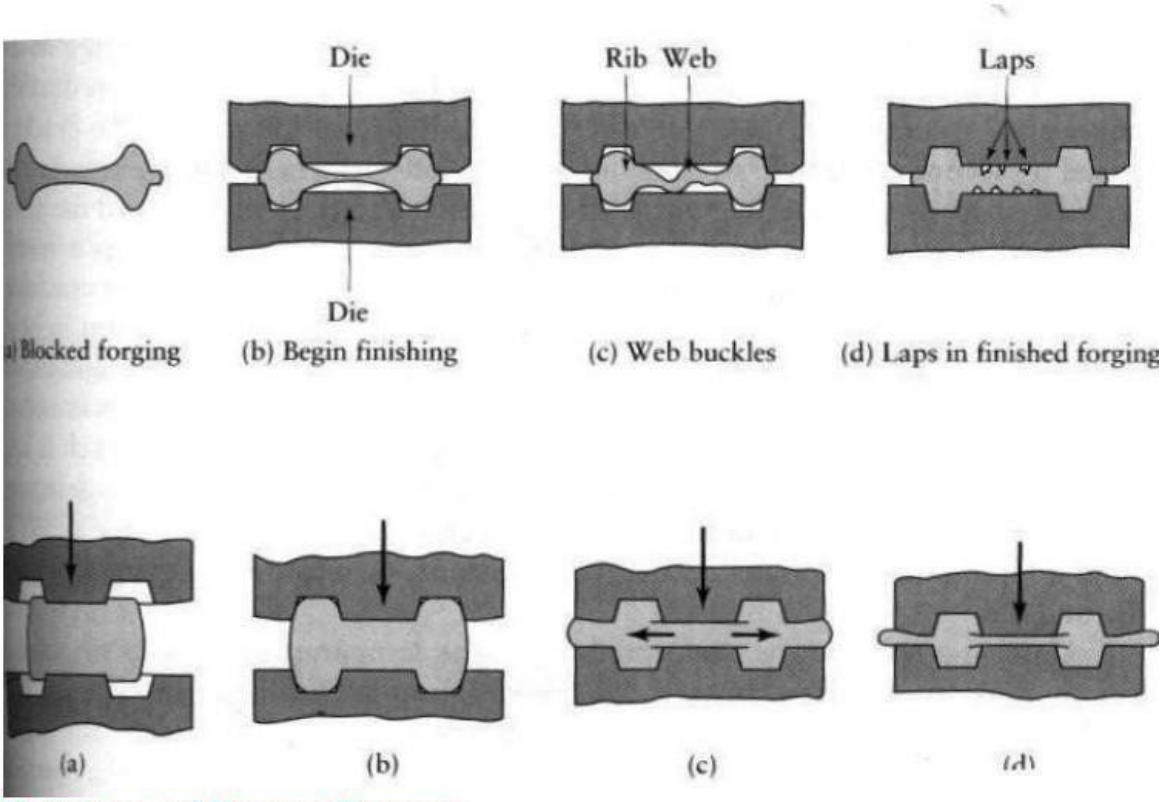


FIGURE 14.16 (a) Schematic illustration of the rotary-swaging process. (b) Forming internal profiles on a tubular workpiece by swaging. (c) A die-closing type swaging machine, showing forming of a stepped shaft. (d) Typical parts made by swaging.

Defects in Forging



Extrusion and Drawing Processes

Extrusion

Process by which long straight metal parts can be produced.
Cross-sections that can be produced vary from solid round, rectangular, to L shapes, T Shapes, tubes and many other different types
Done by squeezing metal in a closed cavity through a die using either a mechanical or hydraulic press.
Extrusion produces compressive and shear forces in the stock.
No tension is produced, which makes high deformation possible without tearing the metal.
Can be done Hot or cold

Drawing

Section of material reduced by pulling through die.
Similar to extrusion except material is under TENSILE force since it is pulled through the die
Various types of sections: - round, square, profiles

Tube Drawing

Utilizes a special tool called a MANDREL is inserted in a tube hollow section to draw a seamless tube

- Mandrel and die reduce both the tube's outside diameter and its wall thickness. The mandrel also makes the tube's inside surface smoother

Sheet Metal Forming

Involves methods in which sheet metal is cut into required dimensions and shape; and/or forming by stamping, drawing, or pressing to the final shape

A special class of metal forming where the thickness of the piece of material is small compared to the other dimensions

Cutting into shape involve shear forces

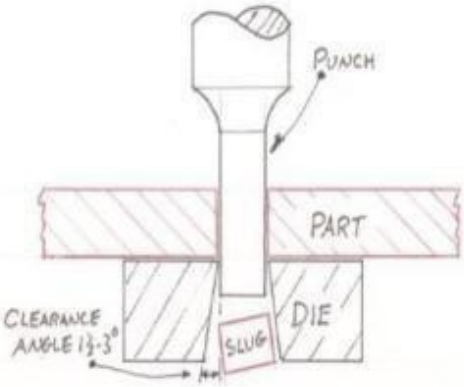
Forming Processes involve tensile stresses

The Major operations of sheet Metal are;

1) Shearing,
2) Bending,
3) Drawing and
4) Squeezing

Shearing

The mechanical cutting of materials without the information of chips or the use of burning or melting for straight cutting blades: shearing for curved blades: blanking, piercing, notching, trimming



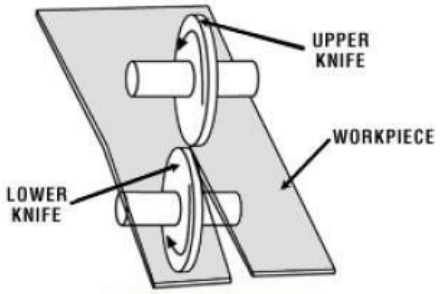
Classifications of Shearing Processes

- Slitting
- Piercing
- Blanking
- Notching
- Shaving
- Trimming
- Cutoff
- Dinking

Slitting

3. Discuss the various forging operations and its types. (16)

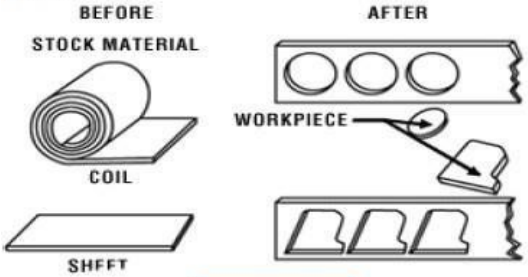
shearing process used to cut rolls of sheet metal into several rolls of narrower width
used to cut a wide coil of metal into a number of narrower coils as the main coil is moved through the slitter.



SLITTING PROCESS

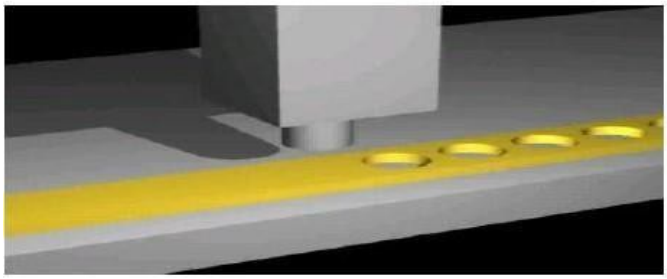
Blanking

during which a metal workpiece is removed from the primary metal strip or sheet when it is punched.



WORKPIECES

Piercing



Notching

same as piercing
- edge of the strip or black forms part of the punch-out perimeter

Nibbling

Produces a series of overlapping slits/notches

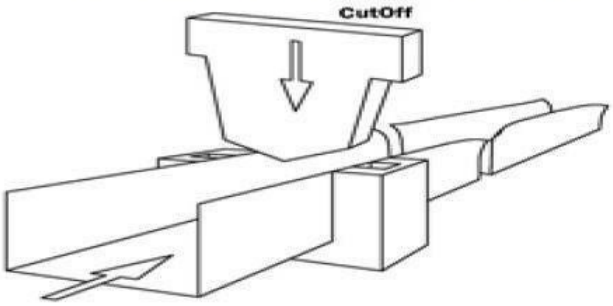
Shaving

- finishing operation in which a small amount of metal is sheared away from the edge of an already blanked part
- can be used to produce a smoother edge

Trimming

Cutoff

Punch and die operation used to separate a stamping or other product from a strip or stock



Dinking

Used to blank shapes from low-strength materials such as rubber, fiber and cloth

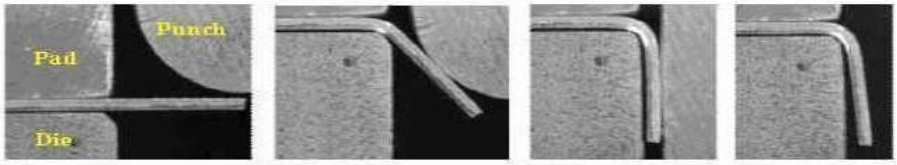
Bending

The plastic deformation of metals about a linear axis with little or no change in the surface area.

The purpose of bending is to form sheet metal along a straight line

Springback

The elastic recovery of the material after unloading of the tools



To compensate with the unbending action of the springback, the metal should be slightly overbent.

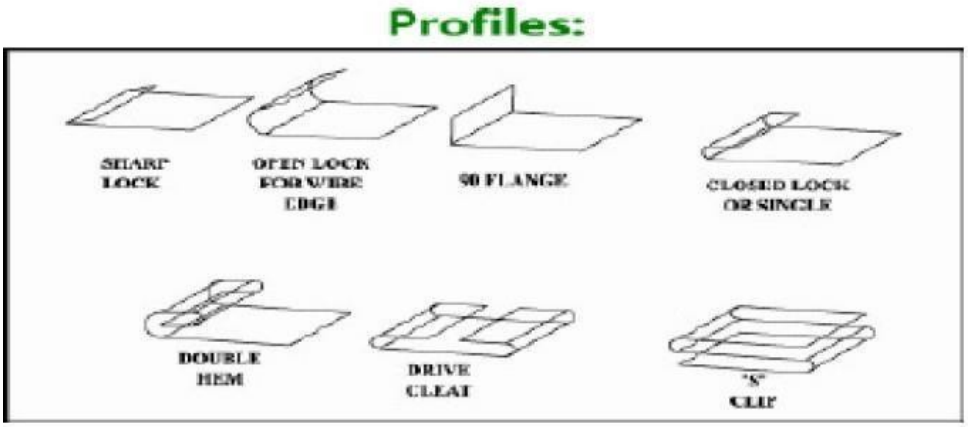
Classifications of Bending Processes

- Angle
- Straightening
- Roll Forming
- Draw and Compression
- Seaming
- Roll
- Flanging

Roll Bending

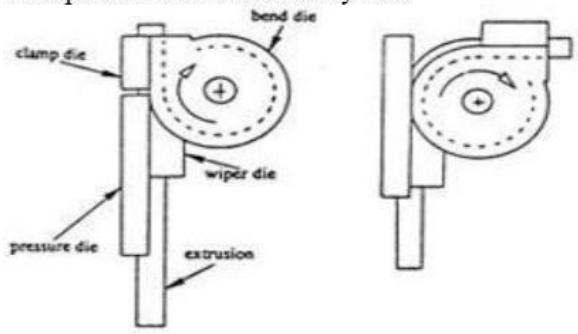
Bending where plates, sheets and rolled shapes can be bent to a desired curvature
Roll bending toll can bend plate up to 6 inches thick

Angle Bending



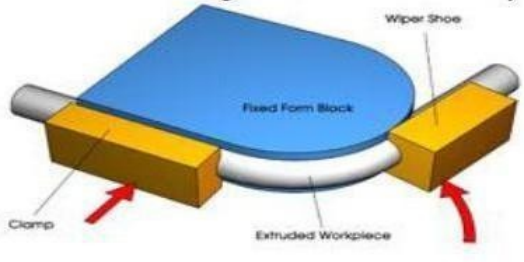
Drawing Bending

Workpiece is clamped against a bending form and the entire assemble rotates to draw the workpiece across a stationary tool



Compression Bending

The bending form remains stationary and the pressure tool moves along the workpiece



Roll Forming

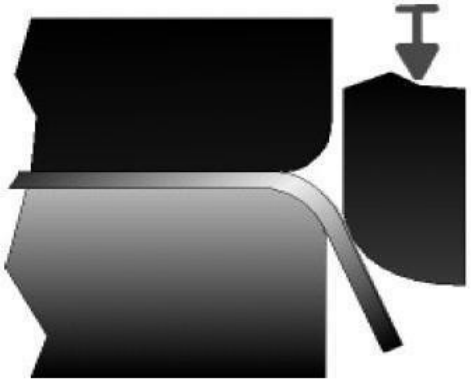
Involves the progressive bending of metal strip as it passes through a series of forming rolls
Any material that can be bent can be roll- formed

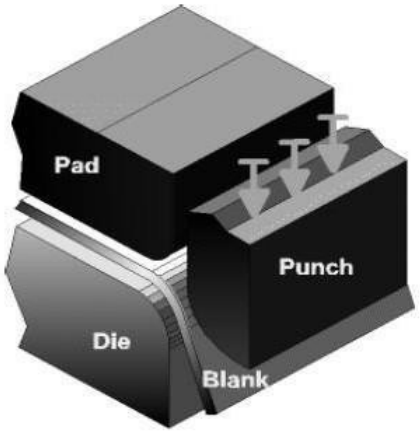
Seaming

- bending operation that can be used to join the ends of sheet metal to form containers such as cans, pails and drums

Flanging

-the process of rolling on sheet metal in essentially the same manner as seaming





Straightening

- also known as flattening
- opposite of bending

Drawing- Stretch forming

Sheet metal clamped along its edges and stretched over a die or form block in required directions.

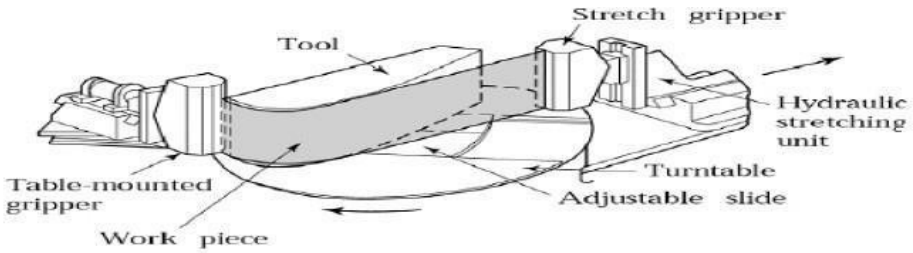


Fig: Schematic illustration of a stretch forming process. Aluminum skins for aircraft can be made by this process

Special Forming Process

There are a great variety of sheet metal forming methods, mainly using shear and tensile forces in the operation.

- Progressive forming
- Rubber hydroforming
- Bending and contouring
- Spinning processes
- Explosive forming
- Shearing and blanking
- Stretch forming
- • Deep drawing

Progressive forming

• Punches and dies are designed so that successive stages in the forming of the part are carried out in the same die on each stroke of the press.
• Progressive dies are also known as multi-stage dies.

Rubber forming

In bending and embossing of sheet metal, the female die is replaced with rubber pad

Hydro-form (or) fluid forming process

The pressure over rubber membrane is controlled throughout the forming cycle ,with max pressure up to 100 Mpi

As a result the friction at the punch-cup interface increases, this increase reduces the longitudinal tensile stresses in the cup and delays fracture

Spinning

Shaping thin sheets by pressing them against a form with a blunt tool to force the material into a desired form

Conventional spinning

A circular blank if flat or performed sheet metal hold against a mandrel and rotated ,while a rigid metal is held against a mandrel and rotated ,wile a rigid tool deforms and shapes the material over the mandrel.

Shear Spinning

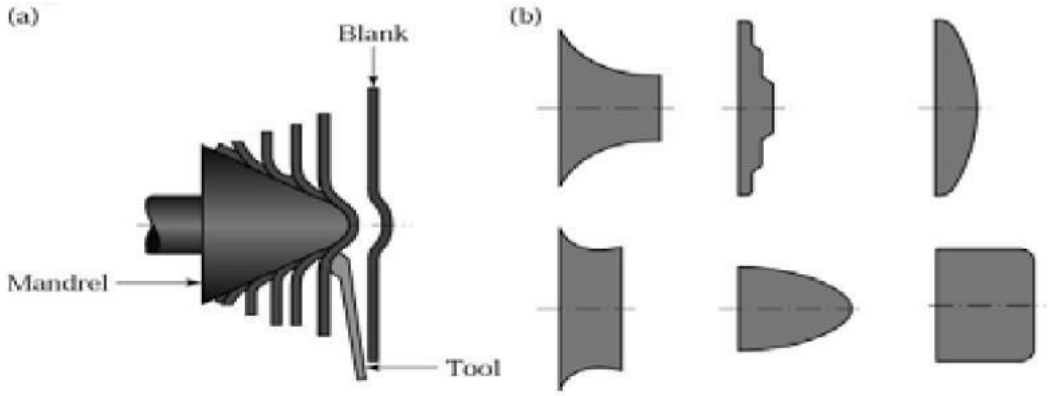
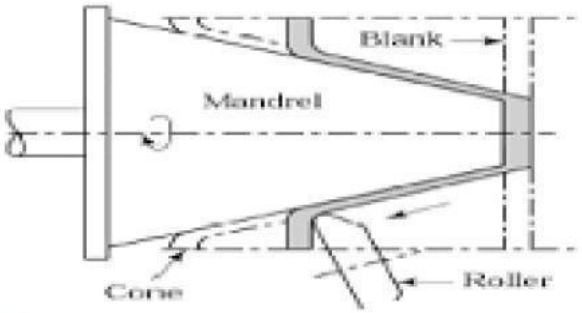


Fig .(a) Schematic illustration of the conventional spinning process (b) Types of parts conventionally spun.

All parts are antisymmetric

- Known as power spinning, flow turning, hydro-spinning, and spin forging
- Produces axisymmetric conical or curvilinear shape
- Single rollers and two rollers can be used
- It has less wastage of material
- Typical products are rocket-

motor casing and missile nose cones.

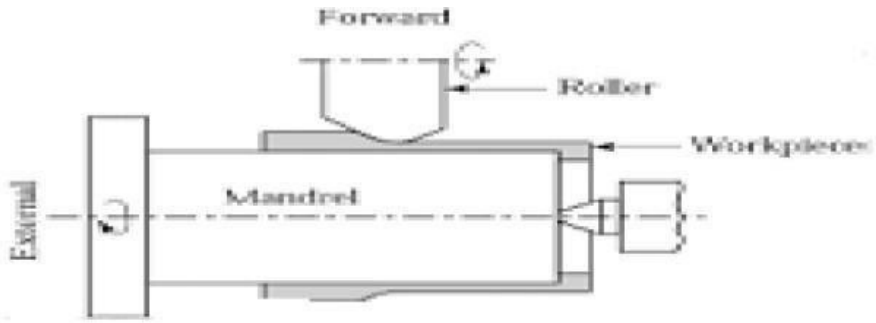


Tube spinning

Thickness of cylindrical parts are reduced by spinning them on a cylindrical mandrel rollers

Parts can be spun in either direction

Large tensile elongation up to 2000 % are obtained within certain temperature ranges and at low strain rates.



Advantages

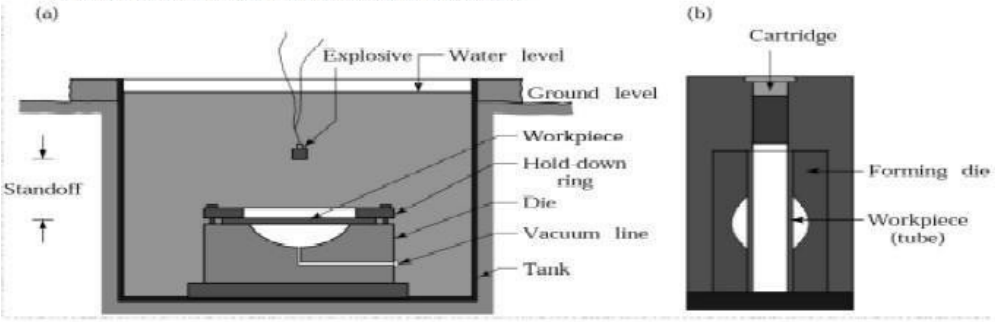
Lower strength is required and less tooling costs
Complex shapes with close tolerances can be made
Weight and material savings
Little or no residual stress occurs in the formed parts

Disadvantages

Materials must not be super elastic at service temperatures
Longer cycle times

Explosive forming

Explosive energy used s metal forming
Sheet-metal blank is clamped over a die
Assembly is immersed in a tank with water
Rapid conversion of explosive charge into gas generates a shock wave .the pressure of this wave is sufficient to form sheet metals



Beading

The periphery if the sheet metal is bent into the cavity of a die

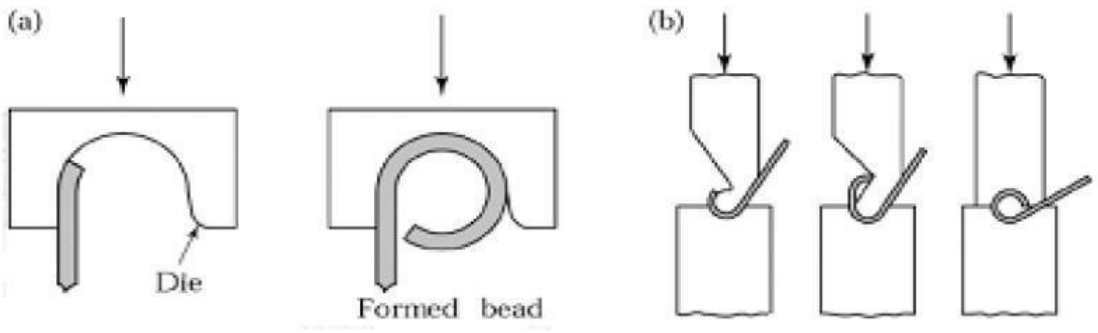


Fig .(a) Bead forming with a single die (b) Bead forming with two dies,in a press brake

Hemming

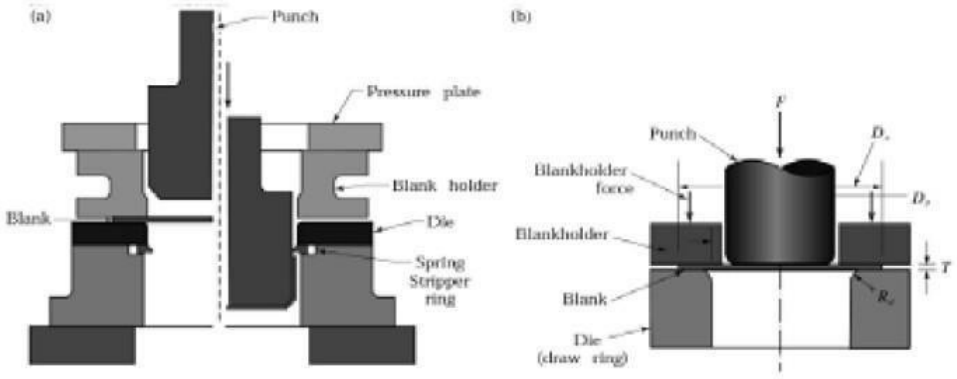
- The edge of the sheet is folded over itself
- This increases stiffness of the part
- The metal strip is bent in stages by passing it through a series of rolls

Seaming

Joining two edges of sheet metal by hemming.Specifically shaped rollers used for watertight and airtight joints

Deep drawing

- Punch forces a flat sheet metal into a deep die cavity.
- Round sheet metal block is placed over a circular die opening and held in a place with blank holder & punch forces down into the die cavity



Flanging

Flanging is a process of bending the edges of sheet metals to 90o
Shrink flanging – subjected to compressive hoop stress.
Stretch flanging –subjected to tensile stresses

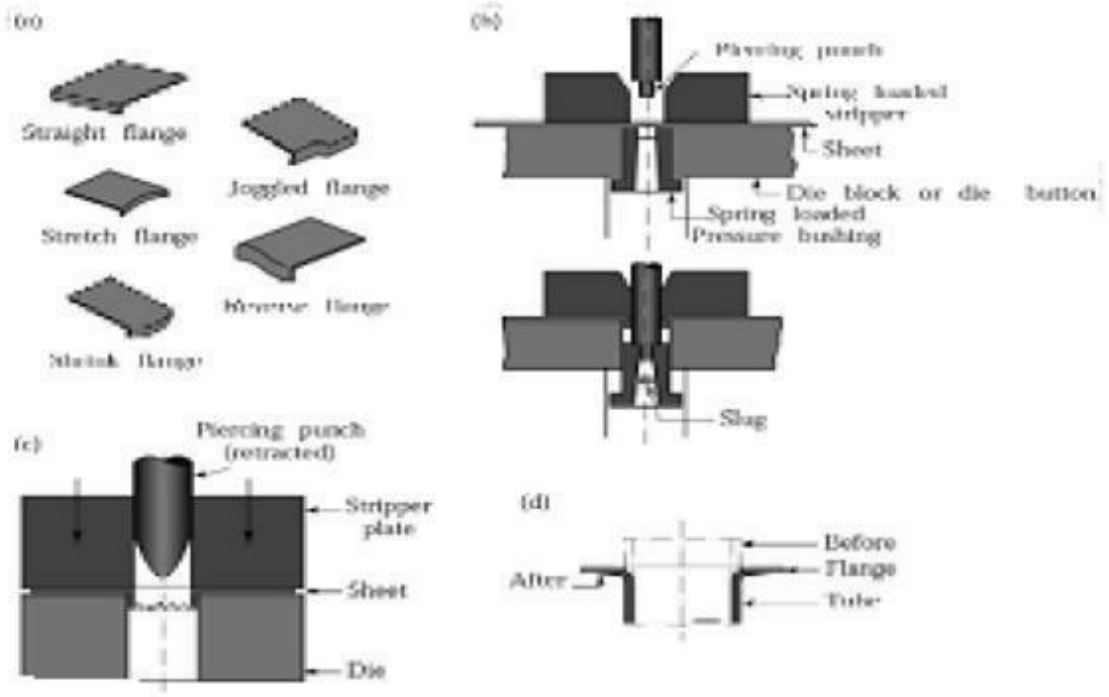


Fig .Various flanging operations (a) Flanges on a flat sheet. (b) Dimpling. (c) The piercing of the sheet metal to form a flange.

In this operation,a hole does not have to be prepunched before the bunch descends .Note however,the rough edges along the circumference of the flange. (d) The flanging of a tube; note the thinning of the edges of the flange

Common Polymers

ABS (Acrylanitrile Butadiene Styrene)
Amorphous, good Impact Strength, excellent appearance, easy to process, computer housings, small appliances, automotive interior, & medical components

Acrylic
Amorphous polymers, excellent clarity, excellent weatherability, optical & outdoor applications

Cellulosics
Among the first thermoplastics developed: smell funny, very flammable

Nylon 6
Semi-crystalline polymer, good cost to performance ratio, lower numbered nylons, absorb moisture and change their properties as a result

Polycarbonate
Amorphous material, excellent Impact Strength, clarity, & optical properties

Polyethylene High Density
widely used, inexpensive, thermoplastic, easy to process, good to excellent chemical resistance, soft & not for use above 150 F.

Polypropylene
semi-crystalline material, low temperature material, excellent chemical resistance difficult to mold to extremely close tolerances

Polystyrene High Impact (HIPS)
few cents more than crystal styrene, to pay for the rubber modifier, opaque & very widely used, lower modulus, better elongation, & less brittle than crystal styrene

PVC Polyvinyl Chloride Rigid
properties similar to ABS (except appearance) at a slightly reduced cost primarily for water pipe and pipe fittings, occasionally for electrical enclosures *in plastic phase PVC is corrosive to molds & machines (non corrosive as a solid)

Characteristics of Forming and Shaping Processes for Plastics and Composite Materials

TABLE 18.1

Process	Characteristics
Extrusion	Long, uniform, solid or hollow complex cross-sections; high production rates; low tooling costs; wide tolerances.
Injection molding	Complex shapes of various sizes, eliminating assembly; high production rates; costly tooling; good dimensional accuracy.
Structural foam molding	Large parts with high stiffness-to-weight ratio; less expensive tooling than in injection molding; low production rates.
Blow molding	Hollow thin-walled parts of various sizes; high production rates and low cost for making containers.
Rotational molding	Large hollow shapes of relatively simple shape; low tooling cost; low production rates.
Thermoforming	Shallow or relatively deep cavities; low tooling costs; medium production rates.
Compression molding	Parts similar to impression-die forging; relatively inexpensive tooling; medium production rates.
Transfer molding	More complex parts than compression molding and higher production rates; some scrap loss; medium tooling cost.
Casting	Simple or intricate shapes made with flexible molds; low production rates.
Processing of composite materials	Long cycle times; tolerances and tooling cost depend on process.

Plastics

Materials that can be reshaped (remolded) by applying heat and pressure. Most plastics are made from synthetic resins (polymers) through the industrial process of polymerization. Two main types of plastics are thermoplastics and thermosets.

Two basic types of plastics

Thermoset- Heat hardening/ Undergoes chemical change
Thermoplastic- Heat softening/ Undergoes physical change

1.Thermosets

General properties: more durable, harder, tough, light.
Typical uses: automobile parts, construction materials

Examples:

Unsaturated Polyesters: lacquers, varnishes, boat hulls, furniture
Epoxies and Resins: glues, coating of electrical circuits, composites: fiberglass in helicopter blades, boats, …

2. Elastomers

General properties: these are thermosets, and have rubber-like properties.
Typical uses: medical masks, gloves, rubber-substitutes

Examples:

Polyurethanes:mattress, cushion, insulation, toys
Silicones:surgical gloves, oxygen masks in medical applications joint seals

3. Thermoplastics

General properties: low melting point, softer, flexible.

Typical uses: bottles, food wrappers, toys, …

Examples:

Polyethylene: packaging, electrical insulation, milk and water bottles, packaging film
Polypropylene: carpet fibers, automotive bumpers, microwave containers, prosthetics
Polyvinyl chloride (PVC): electrical cables cover, credit cards, car instrument panels
Polystyrene: disposable spoons, forks, Styrofoam™
Acrylics (PMMA: polymethyl methacrylate): paints, fake fur, plexiglass
Polyamide (nylon): textiles and fabrics, gears, bushing and washers, bearings
PET (polyethylene terephthalate): bottles for acidic foods like juices, food trays
PTFE (polytetrafluoroethylene): non-stick coating, Gore-Tex™ (raincoats), dental floss

Advantages

Light Weight
High Strenght-to-Weight Ratio
Complex Parts - Net Shape
Variety of Colors (or Clear)
Corrosion Resistant
Electrical Insulation
Thermal Insulation
High Damping Coefficient
"Low" pressures and temp required

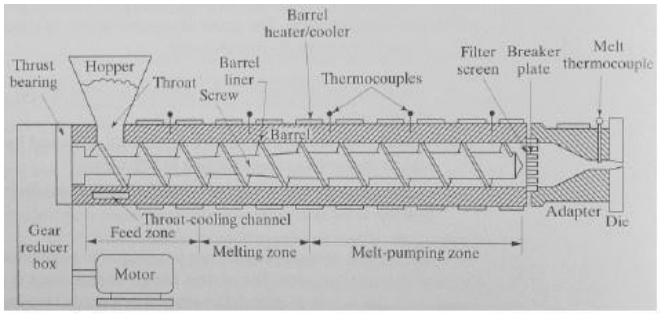
Disadvantages

Creep
Thermally Unstable- Can't withstand Extreme Heat
U-V Light Sensitive
Relatively low stiffness
Relatively low strength
Difficult to Repair/Rework
Difficult to Sort/Recycle

Plastic Manufacturing Processes

A wide variety of plastic manufacturing processes exist

- Extrusion
- Lamination (Calendering)
- Thermal Forming
- Foaming
- Molding
- Expansion
- Solid-Phase Forming
- Casting
- Spinning



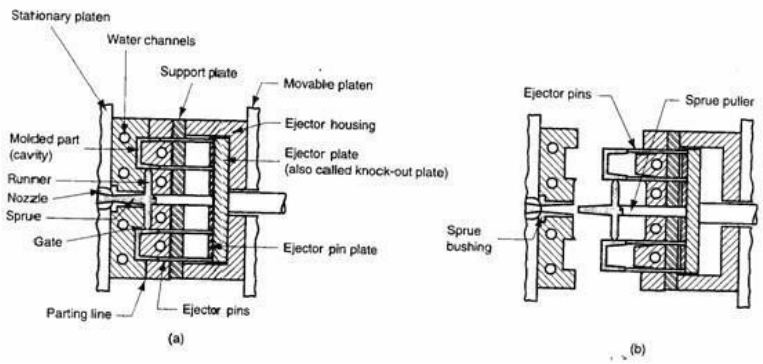
Injection Molding

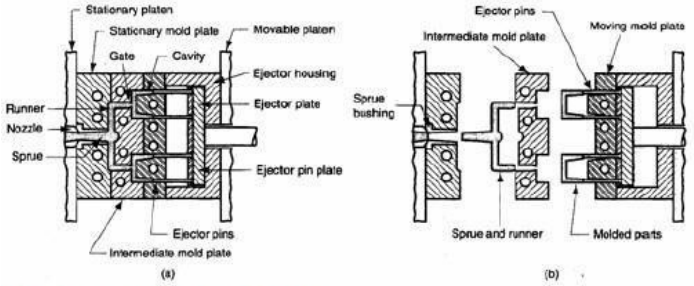
Most widely used process. Suitable for high production of thermoplastics. Charge fed from a hopper is heated in a barrel and forced under high pressure into a mold cavity. Several types. Variety of parts can be made.

Basic components:

mold pieces (define the geometry of the part), and sprue, gates, runners, vents, ejection pins, cooling system

Injection Molding: 2-piece and 3-piece molds





Designing injection molds

1. molding directions --- number of inserts/cams required, if any
2. parting lines

3. parting planes --- by extending the parting line outwards
4. gating design --- where to locate the gate(s) ?
5. multiple cavity mold --- fix relative positions of the multiple parts
6. runners: flow of plastic into the cavity
7. sprue located:
8. functional parts of the mold
- ejection system: to eject the molded part
- systems to eject the solidified runners
- alignment rods: to keep all mold components aligned

Considerations in design of injection molded parts

The two biggest geometric concerns
(i) proper flow of plastic to all parts of the mold cavity before solidification
(ii) shrinking of the plastic resulting in sink holes

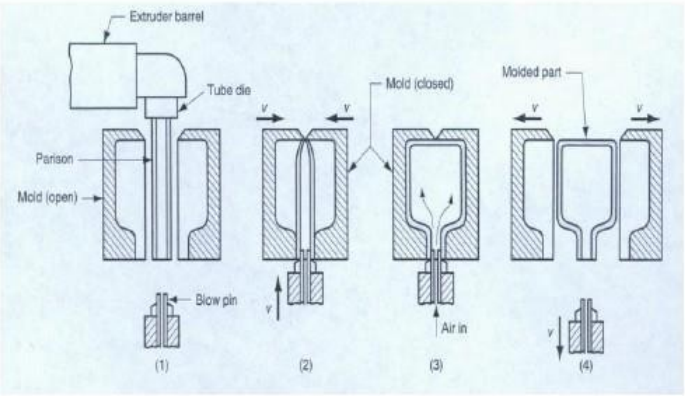
Blow Molding

used to make thermoplastic bottles and hollow sections. Starting material is a round heated solid-bottom hollow tube – perform.

Perform inserted into two die halves and air is blown inside to complete the process

General steps

- Melting the resin- done in extruder
- Form the molten resin into a cylinder or tube (this tube is called parison)
- The parison is placed inside a mold, and inflated so that the plastic is pushed outward against the cavity wall
- The part is allowed to cool in the mold and is then ejected
- The part is trimmed



The parison can be formed by

A)Extrusion process

B)Injection molding process

a)Extrusion blow molding

– Parison is formed from by forcing the plastic through an extrusion die.

- Material enters the die, flow around the mandrel so that extrudate would be cylindrical
- The die would have a hole at the center so that air could be blown into the cylinder
- In some blow molding operations, the air is introduced from the bottom through an inlet

This process can be;

- continuous extrusion blow molding
  - During the process, the extrusion runs continuously, thus making a continuous parison.
  - using multiple mold to match the mold cycle to the extrusion speed
- Intermittent extrusion blow molding
  - During the process, the extruder is stopped during the time that the molding occur
  - use either reciprocating screw or an accumulator system

- In this system, the output of the extruder is matched by having multiple molds which seal and blow the parison and then move away from extruder to cool and eject
- In practical case, the mold cycle is longer than time required to extrude a new parison
- If the mold cycle is twice than time needed for creating a parison, a two mold system can be used
- The method is sometimes called rising mold system - system of which two or more molds are used to mold parts from one extruder during continuous process

b) Injection Blow Molding

- The parison is formed by the injection of molten resin into a mold cavity and around a core pin
- The parison is not a finished product, but it is subjected to subsequent step to form the final shape
- Second step, blowing of the intermediate part in a second mold
- Because of distinct separation of the two steps, the parison made by injection molding is called a perform

Process

- The mold is closed
- Resin is then injected to form a cylindrical part
- The mold is opened and perform is ejected

The perform can be stored until the finished blow molded is needed.

The flexibility of separating the two cycles has proven useful in manufacture of soda pop bottle.

Comparison of extrusion and injection blow molding

Extrusion blow molding

- It is best suited for bottle over 200g in weight, shorter runs and quick tool changeover
- Machine costs are comparable to injection blow molding
- Tooling costs are 50% to 75% less than injection machine

- It requires sprue and head trimming
- Total cycle is shorter than injection (since the parison and blowing can be done using the same machine)
- Wider choice of resin
- Final part design flexibility

Injection blow molding

- Best suited for long runs and smaller bottles
- No trim scrap
- Higher accuracy in final part
- Uniform wall thickness
- Better transparencies with injection blow molding, because crystallization can be better controlled
- Can lead to improve mechanical properties from improved parison design.

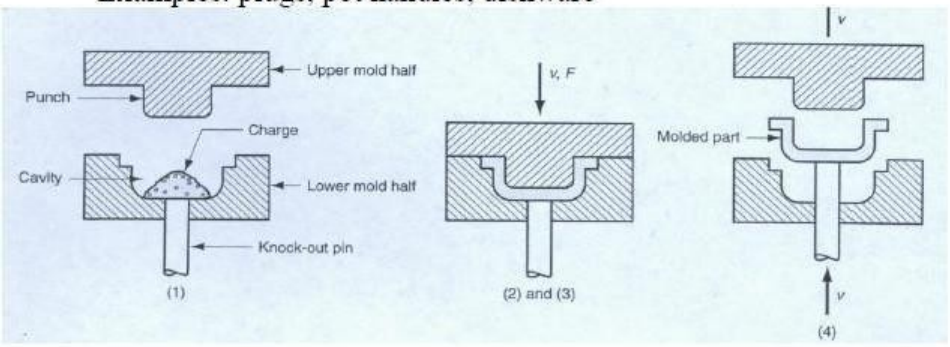
Common plastics for blow molding

- HDPE (stiff bottle, toys, cases, drum)
- LDPE (flexible bottle)
- PP (higher temperature bottle)
- PVC (clear bottle, oil resistant containers)
- PET (soda pop bottle)
- Nylon (automotive coolant bottle, power steering reservoir)

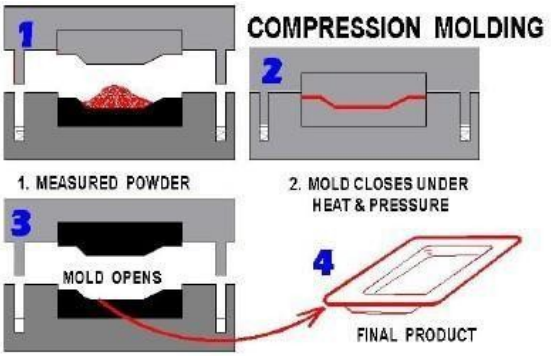
Compression Molding

- The process of molding a material in a confined shape by applying pressure and usually heat.
- Almost exclusively for thermoset materials
- Used to produce mainly electrical products

Thermoset granules are "compressed" in a heated mold to shape required.
Examples: plugs, pot handles, dishware



Process



Transfer Molding

- A process of forming articles by fusing a plastic material in a chamber then forcing the whole mass into a hot mold to solidify.
- Used to make products such as electrical wall receptacles and circuit breakers
- Similar to compression molding except thermosetting charge is forced into a heated mold cavity using a ram or plunger.
  Examples: electrical switchgear, structural parts

Process Variables

- Amount of charge
- Molding pressure
- Closing speed
- Mold temperature
- Charge temperature
- Cycle time

Advantages

- Little waste (no gates, sprues, or runners in many molds)
- Lower tooling cost than injection molding
- Good surface finish
- Less damage to fibers
- Process may be automated or hand-operated
- Material flow is short, less chance of disturbing inserts, causing product stress, and/or eroding molds.

Disadvantages

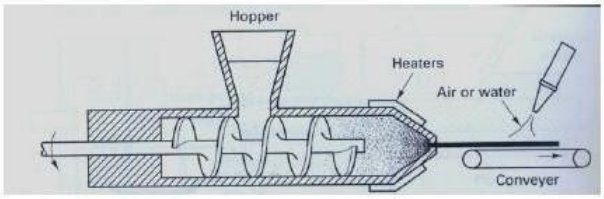
- High initial capital investment
- Labor intensive
- Secondary operations maybe required
- Long molding cycles may be needed.

Cold Molding

Charge is pressed into shape while cold then cured in an oven. Economical but usually poor surface finish

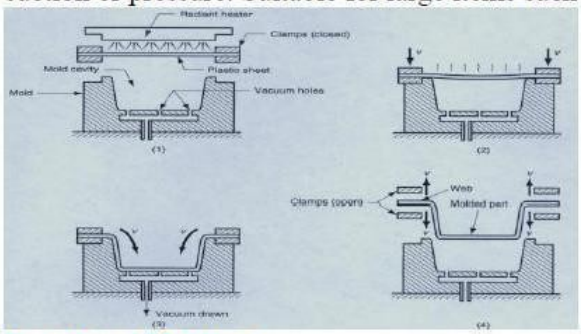
Extrusion

Extrusion is the process of squeezing metal in a closed cavity through a tool, known as a die using either a mechanical or hydraulic press.
Similar to injection molding except long uniform sections are produced –e.g. pipes, rods, profiles.
Extrusion often minimizes the need for secondary machining,and as a result could result in financial savings. However extruded objects are not of the same dimensional accuracy or surface finish as machined parts.



Thermoforming

Sheet material heated to working temperature then formed into desired shape by vacuum suction or pressure. Suitable for large items such as bath tubs



Rotational Molding

Used to form hollow seamless products such as bins. Molten charge is rotated in a mold in two perpendicular axes simultaneously, or rotated while tilting.

Foam Molding

Foaming agent is combined with the charge to release gas, or air is blown into mixture while forming.

Used to make foams. Amount of gas determines the density

Calendaring:

Molten plastic forced between two counter-rotating rolls to produce very thin sheets e.g. polyethylene sheets

Spinning

Modified form of extrusion in which very thin fibers or yarns are produced

Machining

Material removal process such as drilling, turning, thread cutting. E.g. nylon fasteners. In general thermoplastics have poor machinability.

Production Technology (25ME304)