MANUFACTURING PROCESS

ES-119 UNIT -4

Department of Applied Sciences, BVCOE New Delhi

POWDER METALLURGY

Powder Metallurgy

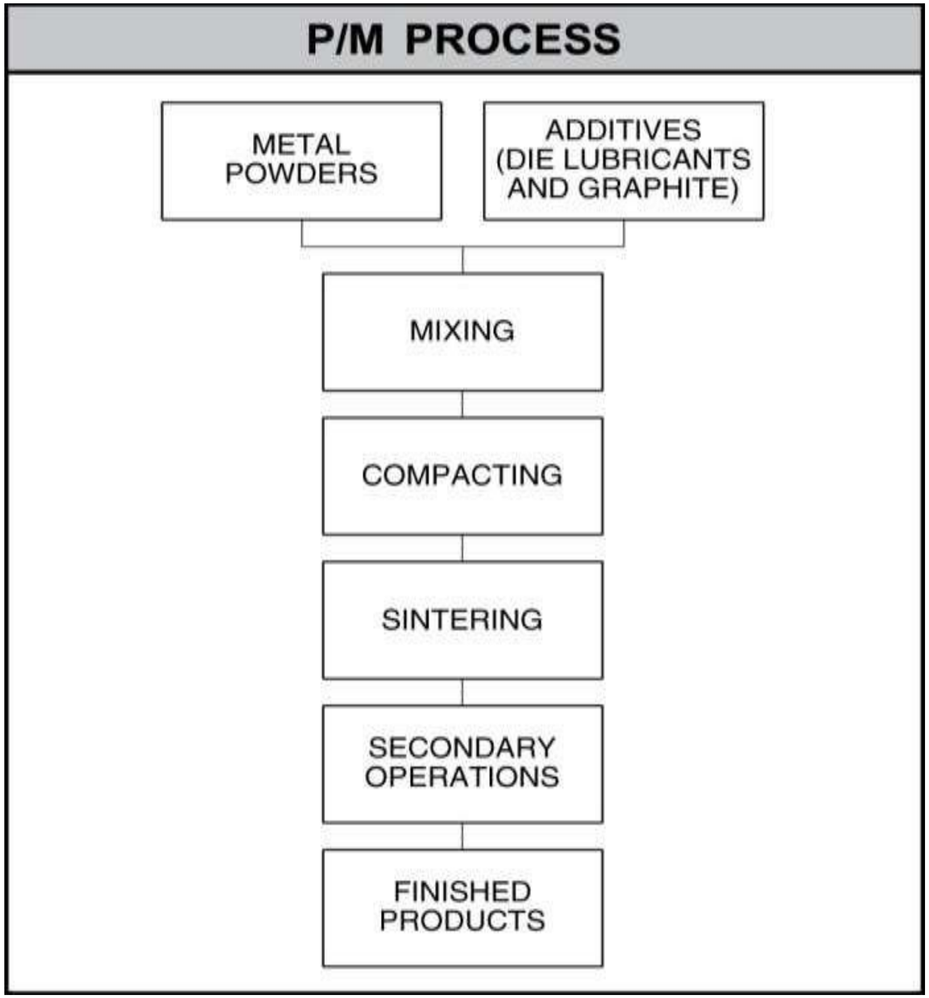
- Essentially, Powder Metallurgy (PM) is an art & science of producing metal or metallic powders, and using them to make finished or semi-finished products.
- Particulate technology is probably the oldest forming technique known to man.
- There are archeological evidences to prove that the ancient man knew something about it.

Powder Metallurgy

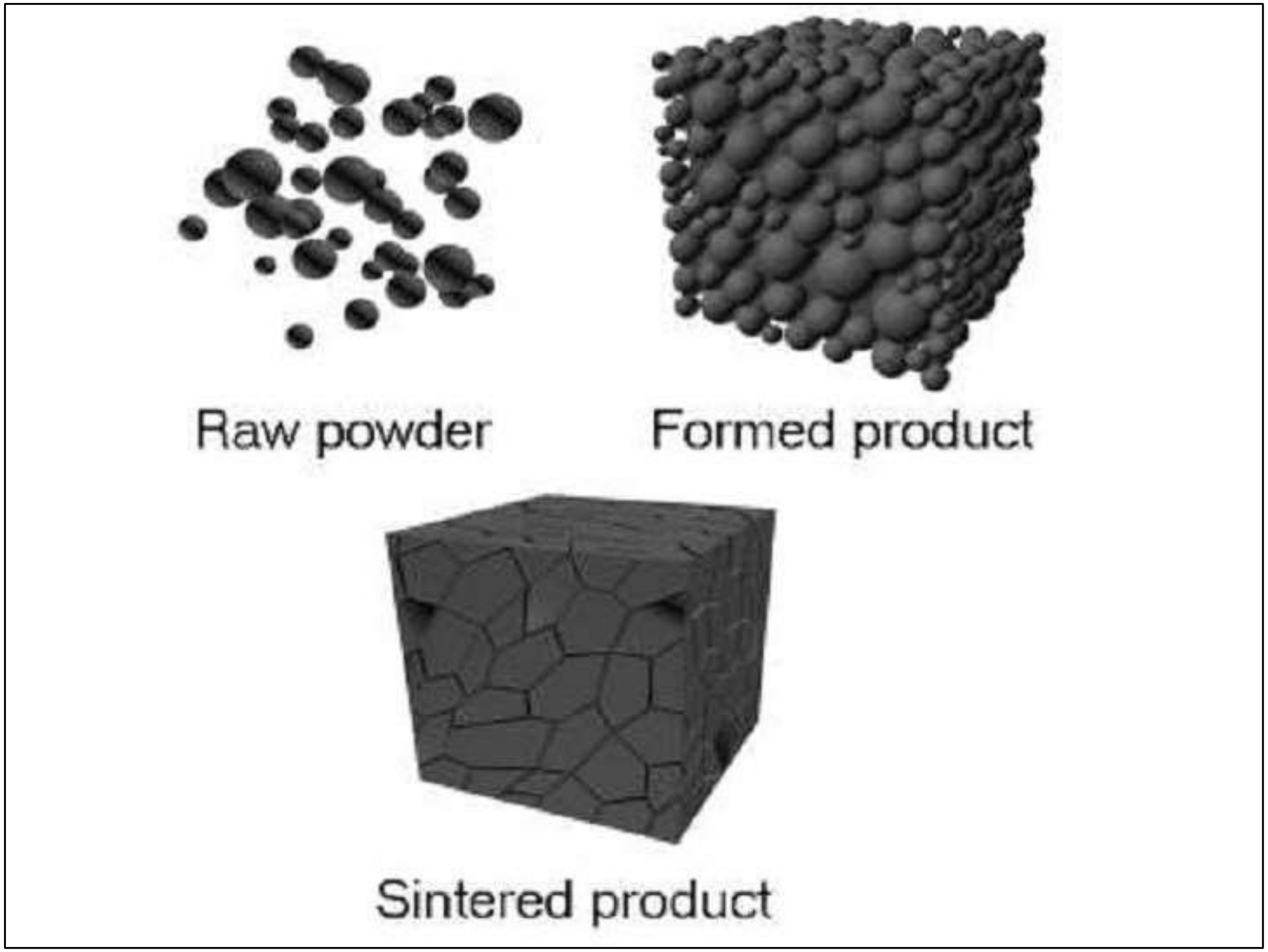
- An important point that comes out :
  - **The entire material need not be melted to fuse it.**
- The working temperature is well below the melting point of the major constituent, making it a very suitable method to work with refractory materials, such as: W, Mo, Ta, Nb, oxides, carbides, etc.
- It began with Platinum technology about 4 centuries ago… in those days, Platinum, [MP = 1774°C], was "refractory", and could not be melted.

Powder Metallurgy Process

- Powder production
- Blending or mixing
- Powder compaction
- Sintering
- Finishing Operations



Powder Metallurgy Process



Powder Metallurgy Processing

POWDER →

- Powder fabrication
- Size and shape characterization
- Microstructure (e.g.. dendrite size)
- Chemical homogeneity, and ppt. size

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PROCESSING →

- Compaction
- Sintering
- Forging/Hot pressing

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PROPERTIES →

- Density, Porosity
- Ductility, Strength
- Conductivity
- Other functional properties

Usual PM production sequence

Blending and mixing (Rotating drums, blade and screw mixers)

Pressing - powders are compressed into desired shape to produce green compact

Accomplished in press using punch-and-die tooling designed for the part

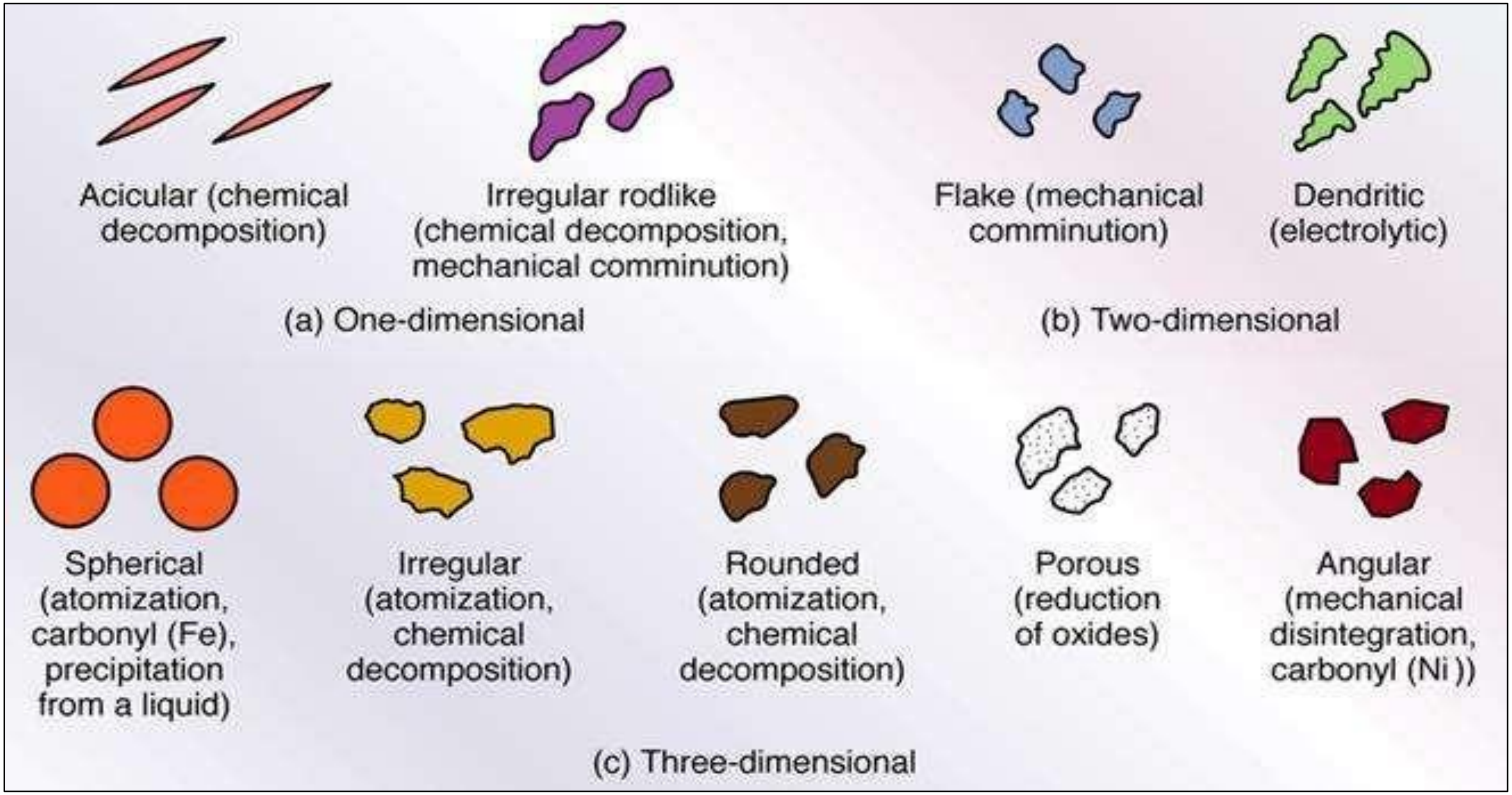
Sintering – green compacts are heated to bond the particles into a hard, rigid mass.

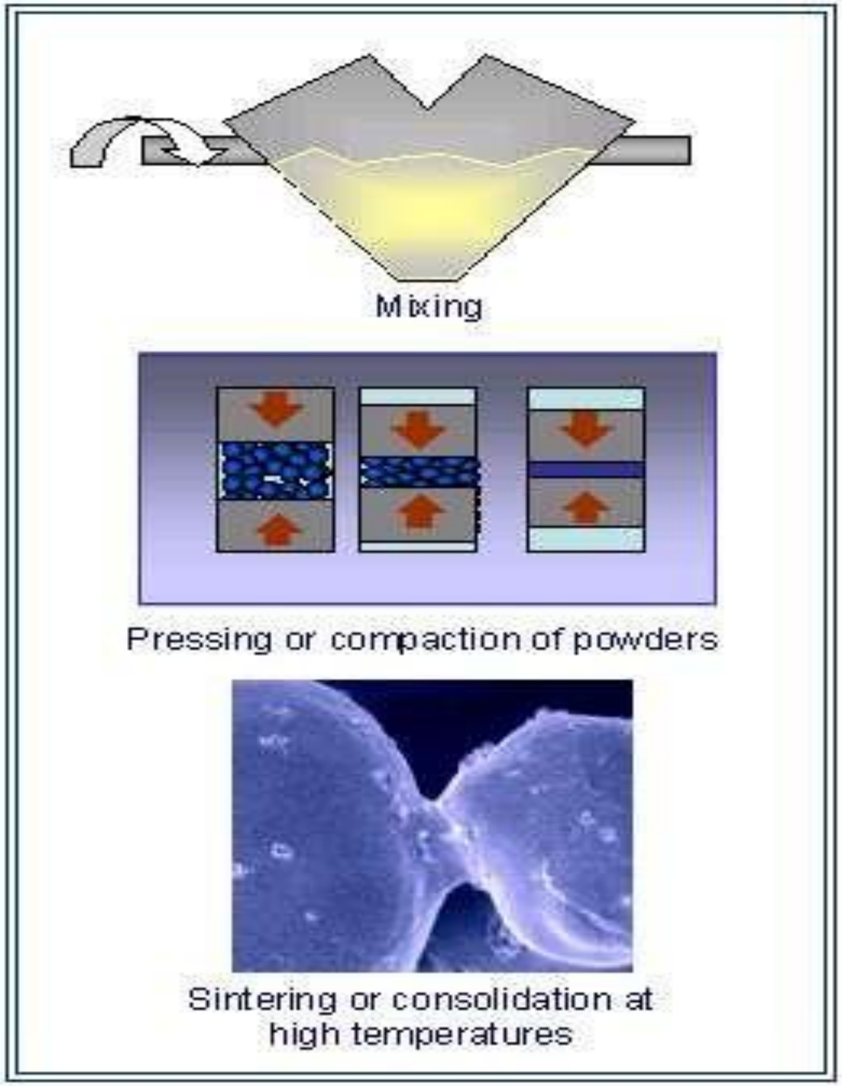
Performed at temperatures below the melting point of the metal

Production of Metallic Powders

- In general, producers of <u>metallic powders</u> are not the same companies as those that make <u>PM parts</u>
- <u>Any metal</u> can be made into <u>powder form</u>
- Three principal methods by which metallic powders are commercially produced
    - Atomization (by gas, water, also centrifugal one)
    - Chemical
    - Electrolytic
- In addition, <u>mechanical methods</u> are occasionally used to <u>reduce powder sizes</u>

Particle Shapes in Metal Powders



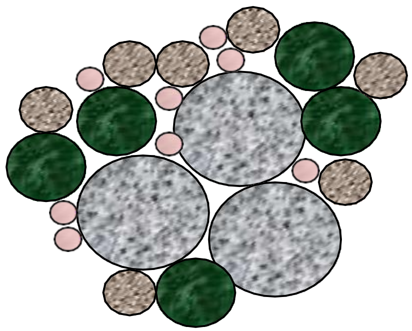


Conventional powder metallurgy production sequence:

- blending
- compacting
- Sintering

Blending and Mixing of Powders

For successful results in compaction and sintering, the starting powders must be homogenized (powders should be blended and mixed).



- Blending - powders of same chemistry but possibly different particle sizes are intermingled
  - Different particle sizes are often blended to reduce porosity

- Mixing - powders of different chemistries are combined .

PM technology allows mixing various metals into alloys that would be difficult or impossible to produce by other means.

Blending or Mixing

- Blending a coarser fraction with a finer fraction ensures that the interstices between large particles will be filled out.
- Powders of different metals and other materials may be mixed in order to impart special physical and mechanical properties through metallic alloying.
- Lubricants may be mixed to improve the powder's flow characteristics.
- Binders such as wax or thermoplastic polymers are added to improve green strength.

Blending

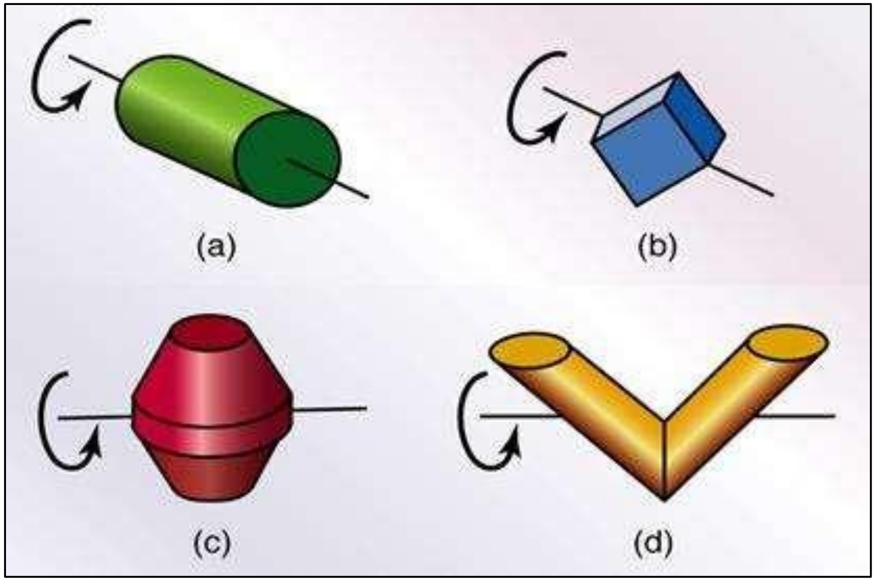
To make a homogeneous mass with uniform distribution of particle size and composition.

- Powders made by different processes have different sizes and shapes
- Mixing powders of different metals/materials

Combining is generally carried out in

- Air or inert gases to avoid oxidation
- Liquids for better mixing, elimination of dusts and reduced explosion hazards

Bowl Geometries



Some common equipment geometries used for blending powders
(a) Cylindrical, (b) rotating cube, (c) double cone, (d) twin shell

A mixer suitable for blending metal powders.

Compaction

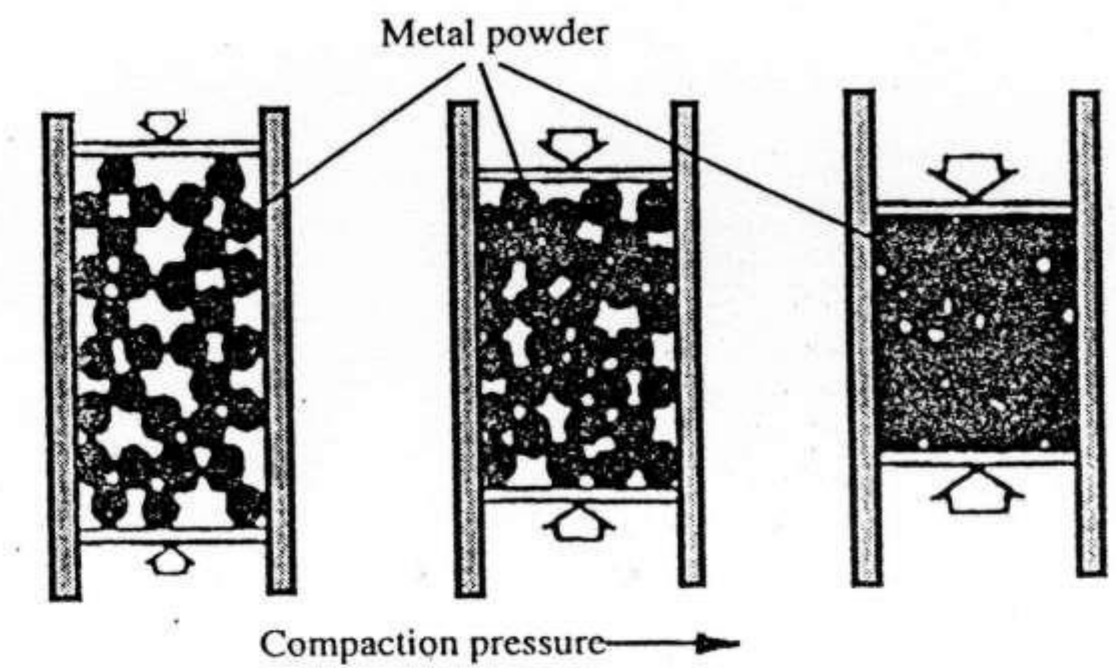
Application of high pressure to the powders to form them into the required shape.

Conventional compaction method is pressing, in which opposing punches squeeze the powders contained in a die.

- The work part after pressing is called a green compact, the word green meaning not yet fully processed.
- The green strength of the part when pressed is adequate for handling but far less than after sintering.

Compacting

- Press powder into the desired shape and size in dies using a hydraulic or mechanical press
- Pressed powder is known as “green compact”
- Stages of metal powder compaction:



Compacting

Powders do **not flow** like liquid, they simply **compress** until an equal and opposing force is created.

– This opposing force is created from a combination of

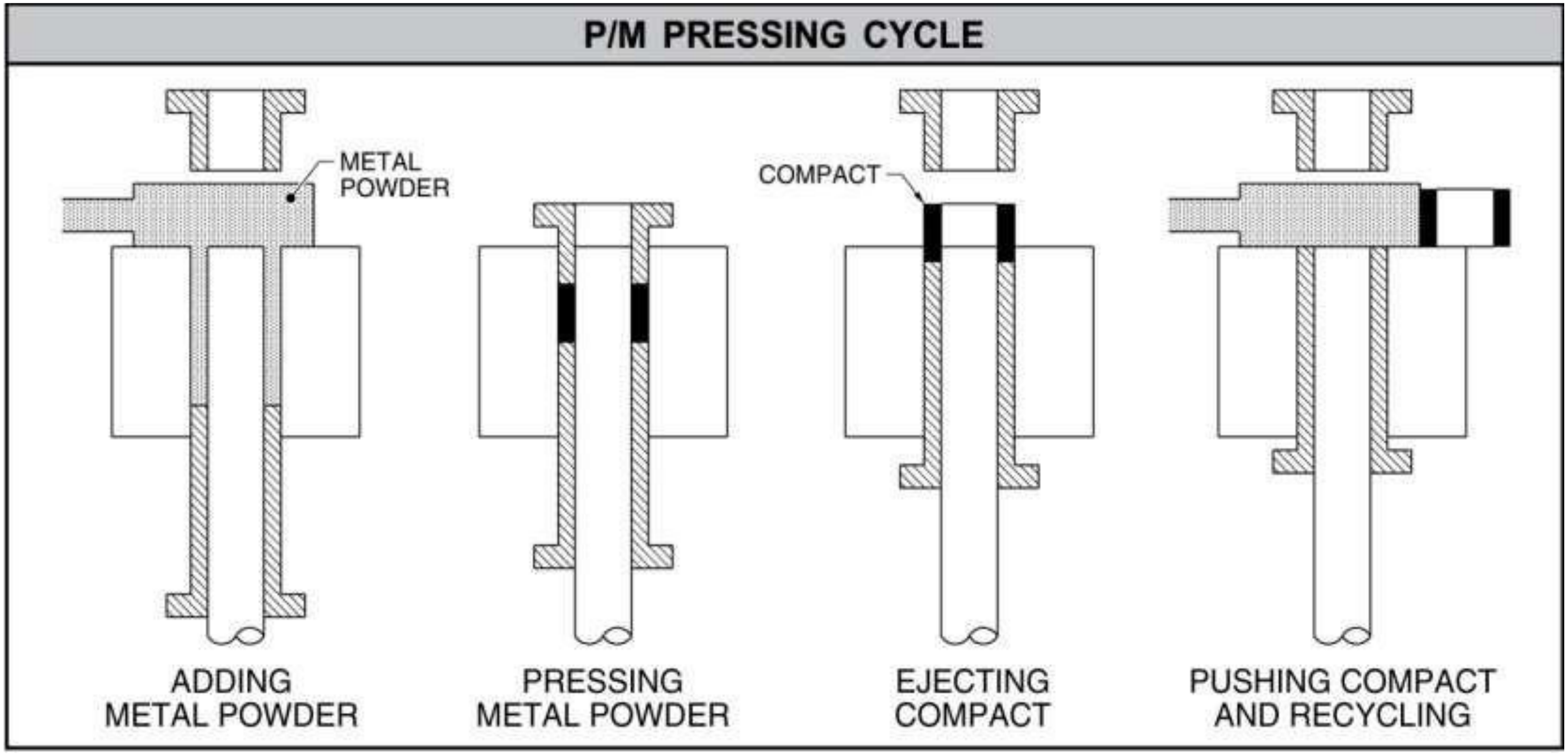
(1) resistance by the bottom punch and

(2) friction between the particles and die surface

Compacting consolidates and dandifies the component for transportation to the sintering furnace.

Compacting consists of automatically feeding a controlled

Compacting



Compacting is usually performed at room temperature. Pressures range from 10 tons per square inch (tons/in^2) (138 MPa) to 60 tons/in^2 (827 MPa), or more.

Figure: (Left) Typical press for the compacting of metal powders. A removable die set (right) allows the machine to be producing parts with one die set while another is being fitted to produce a second product.

Compaction

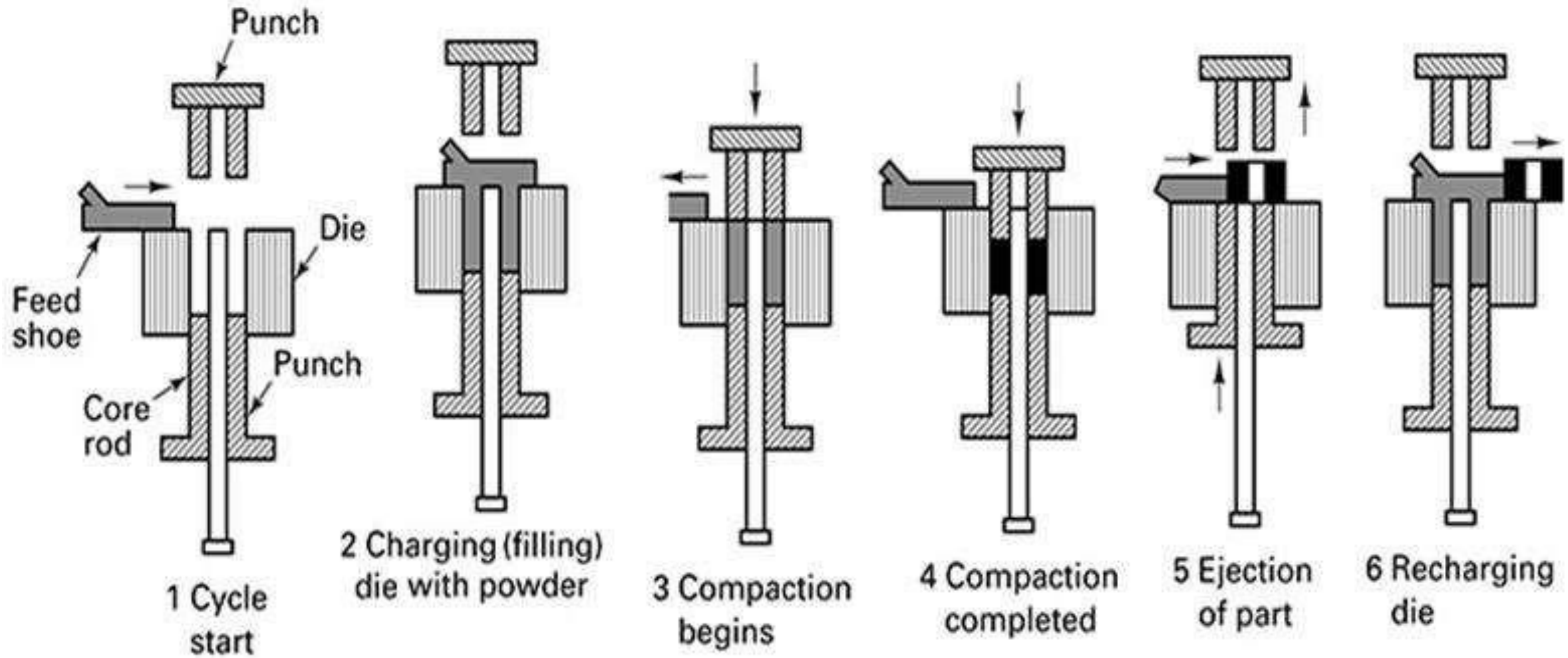
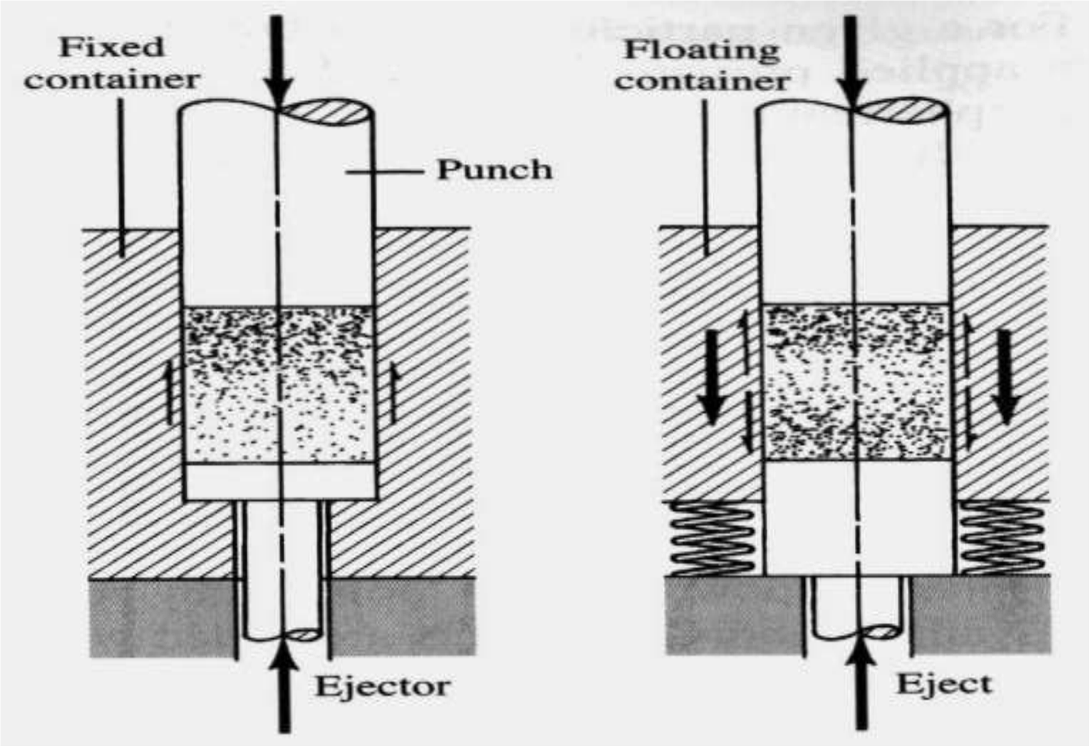


Figure: Typical compaction sequence for a single-level part, showing the functions of the feed shoe, die core rod, and upper and lower punches. Loose powder is shaded; compacted powder is solid black.

Friction problem in cold compaction



Sintering

Heat treatment to bond the metallic particles, thereby increasing strength and hardness.

Usually carried out at between 70% and 90% of the metal's melting point (absolute scale)

- Generally agreed among researchers that the primary driving force for sintering is reduction of surface energy
- Part shrinkage occurs during sintering due to pore size reduction

Sintering

- Parts are heated to ~80% of melting temperature.
- Transforms compacted mechanical bonds to much stronger metal bonds.
- Many parts are done at this stage. Some will require additional processing.

Sintering Sequence

- Parts are heated to 0.7~0.9 T_m.
- Transforms compacted mechanical bonds to much stronger metallic bonds.

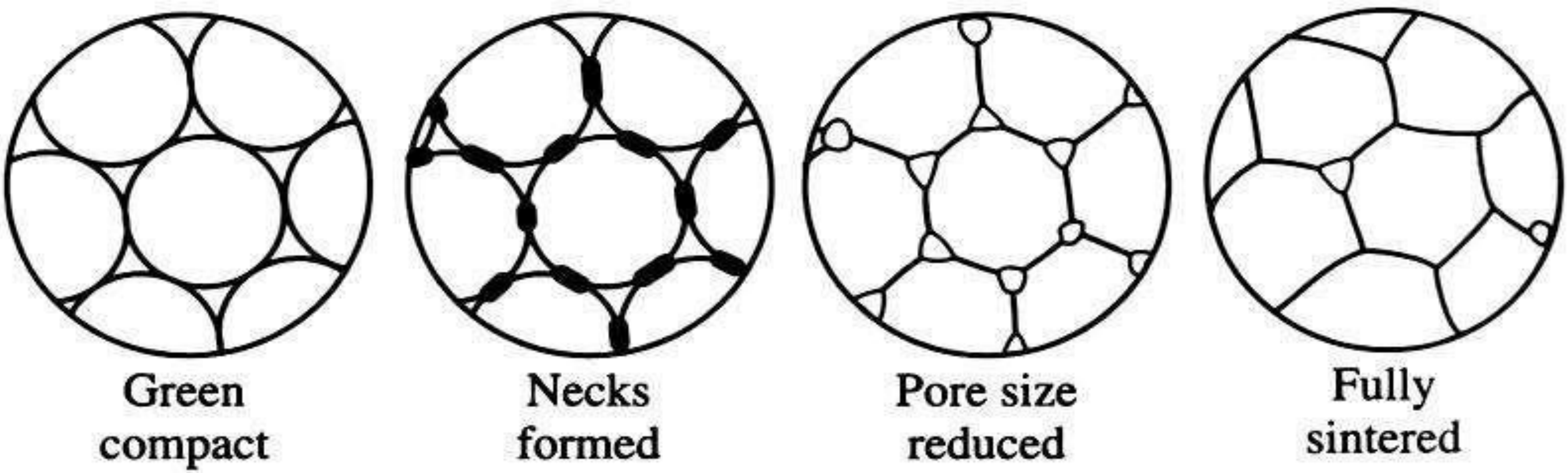


Figure: Sintering on a microscopic scale: (1) particle bonding is initiated at contact points; (2) contact points grow into "necks"; (3) the pores between particles are reduced in size; and (4) grain boundaries develop between particles in place of the necked regions.

Sintering

Third stage:

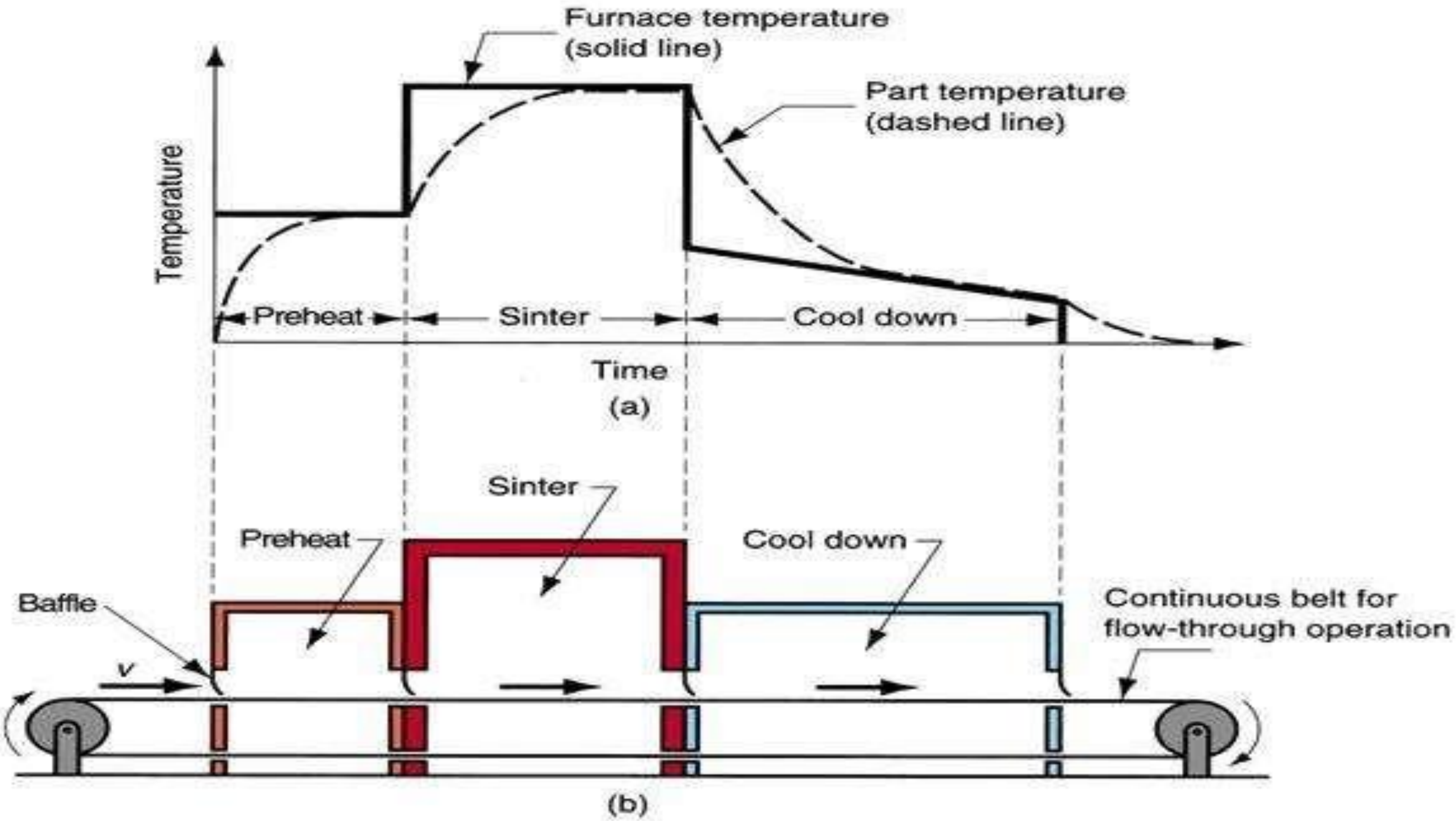
Sintered product is cooled in a controlled atmosphere.

- Prevents oxidation and thermal shock

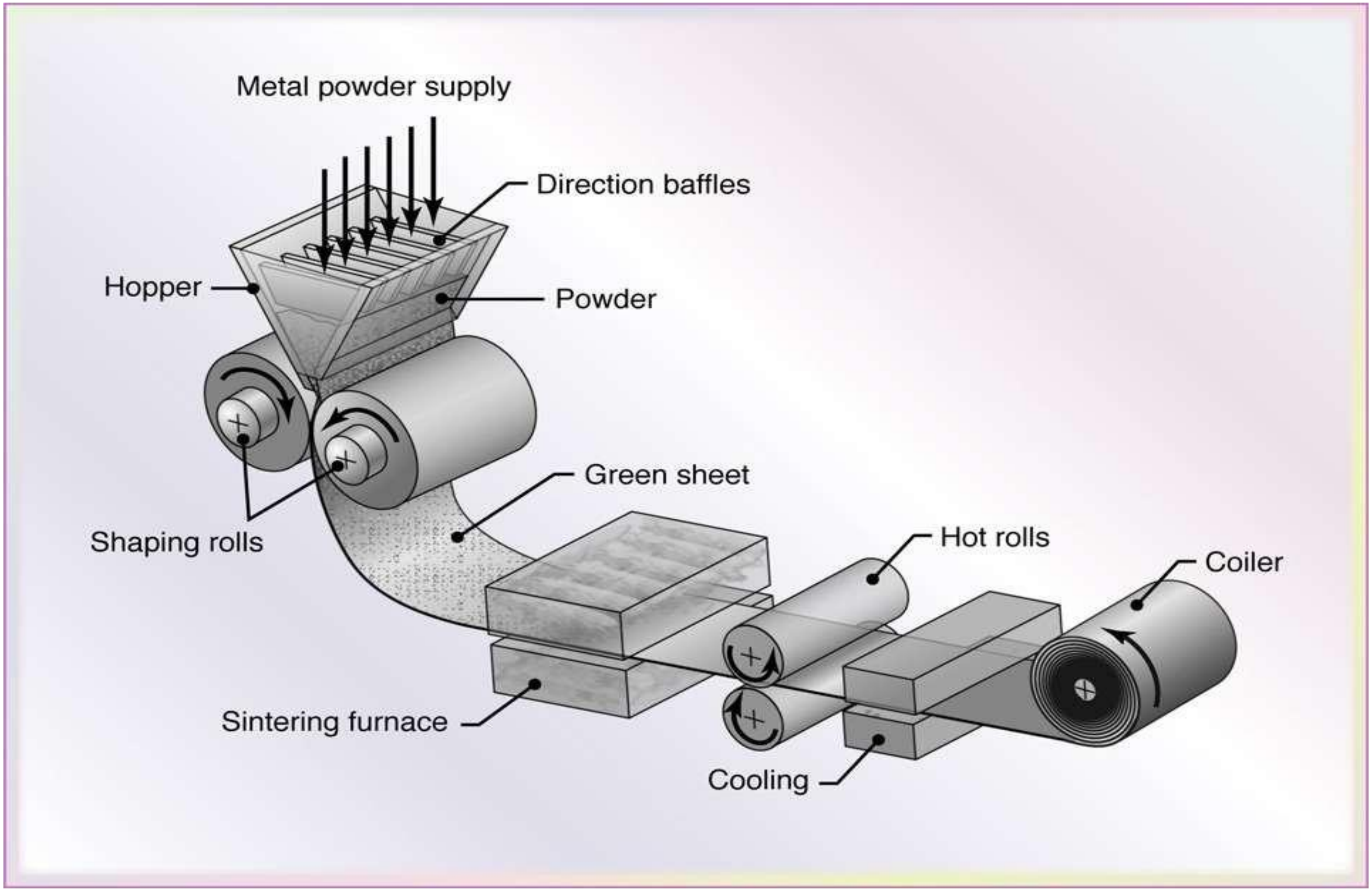
Gases commonly used for sintering:

H_2, N_2, inert gases or vacuum

Sintering Cycle and Furnace



Powder Rolling



Powder Metallurgy Merits

- Precision parts can be produced
- The production can be fully automated, therefore,
- Mass production is possible
- Production rate is high
- Over-head costs are low
- Break even point is not too large
- Material loss is small

Advantages of P/M

- Virtually unlimited choice of alloys, composites, and associated properties
  - Refractory materials are popular by this process
- Can be very economical at large run sizes (100,000 parts)
- Long term reliability through close control of dimensions and physical properties
- Wide latitude of shape and design
- Very good material utilization

Limitations and Disadvantages

- High tooling and equipment costs.
- Metallic powders are expensive.
- Problems in storing and handling metal powders.
  - Degradation over time, fire hazards with certain metals
- Limitations on part geometry because metal powders do not readily flow laterally in the die during pressing.
- Variations in density throughout part may be a problem, especially for complex geometries.

Powder Metallurgy Disadvantages

- Porous !! Not always desired.
- Large components cannot be produced on a large scale.
- Some shapes are difficult to be produced by the conventional p/m route.

Whatever, the merits are so many that P/M, as a forming technique, is gaining popularity

PM Parts

Powdered Metal Transmission Gear

- Warm compaction method with 1650-ton press
- Teeth are molded net shape: No machining
- UTS = 155,000 psi
- 30% cost savings over the original forged part

Connecting Rods:
Forged on left; P/M on right

Unit 4

SEMESTER I

Manufacturing of Plastic Components

INTRODUCTION

■**Plastic**

• Plastic is the general common term for a wide range of synthetic or semi synthetic organic amorphous solid materials suitable for the manufacture of industrial products.
• Plastics are typically polymers of high molecular weight, and may contain other substances to improve performance and/or reduce costs.

Types of Plastics

• Plastics can be divided into two major categories:

1. **Thermoset or thermosetting plastics.** Once cooled and hardened, these plastics retain their shapes and cannot return to their original form. They are hard and durable. Thermosets can be used for auto parts, aircraft parts and tires.
Examples include polyurethanes, polyesters, epoxy resins and phenolic resins.

2. **Thermoplastics.** Less rigid than thermosets, thermoplastics can soften upon heating and return to their original form. They are easily molded and extruded into films, fibers and packaging.
Examples include polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC).

Thermoset or Thermosetting Plastics

1. **Polyurethane Plastics** :- Polyurethane plastics belong to the group that can be thermosetting. Polyurethane is the only plastic which can be made in both rigid and flexible foams. The flexible polyurethane foam is used in mattresses, carpets, furniture etc. The rigid polyurethane foam is used in chair shells, mirror frames and many more. Due to the property of high elasticity, some polyurethane plastics are used in decorative and protective coatings. The high elasticity makes these polyurethane plastics resistant to a chemical attack.

2. **Epoxy**

Epoxies are used in numerous ways. In combination with glass fibers, it is capable of producing composites that are of high strength and that are heat resistant. This composite is typically used for filament wound rocket motor casings in missiles, in aircraft components, and in tanks, pipes, tooling jigs pressure vessels, and fixtures. Epoxies are also found in gymnasium floors, industrial equipment, sealants, and protective coatings in appliances.

3. **Phenolic**

Phenolic plastics are thermosetting resins used in potting compounds, casting resins, and laminating resins. They can also be used for electrical purposes and are a popular binder for holding together plies of wood for plywood.

Thermoplastics

1.Vinyl Plastics :-

Vinyl plastics belong to the thermoplastic group. Vinyl plastics are the sub-polymers of vinyl derivatives. These are used in laminated safety glasses, flexible tubing, molded products etc.

2.Polyacrylics Plastics :- Polyacrylics belong to the group of thermoplastics. Polyacrylics are transparent , decorative and can be shaped in any form like the windshields for airplane.

3.Polyvinyl Chloride

Polyvinyl Chloride, commonly referred to as PVC or vinyl, was first invented in Germany around 1910. It didn't become a useful product in the United States, however, until the late 1920s. It became particularly useful during World War II when it was used as a substitute for rubber, which was in short supply. Polyvinyl Chloride is resistant to abrasion and is both weather and chemical resistant. Today, it is commonly found in upholstery, wall coverings, flooring, siding, pipe, and even apparel. In fact, vinyl is perhaps the best known of all plastics.

4.Polyethylene Terephthalate (PETE) :- PETE is one the most recycled plastic. It finds usage in various bottles like that of soda and cooking oil, etc.

5.High Density Polyethylene (HDPE):-HDPE is generally used in detergent bottles & in milk jugs.

6.Polyvinyl Chloride (PVC) :- PVC is commonly used in plastic pipes, furniture, water bottles, liquid detergent jars etc.

7.Low Density Polyethylene (LDPE) :- LDPE finds its usage in dry cleaning bags, food containers

8.Polypropylene (PP) :- PP is commonly used in bottle caps and drinking straws.

9.Polystyrene (PS) :- PS is used in cups, plastic tableware etc.

Characteristics of Plastics

- **Mechanical properties**

Mechanical properties refer to displacement or breakage of plastic due to some mechanical change such as applying some load. Mechanical properties are dependent on the temperature, force (load), and the duration of time the load is applied.

- **Thermal properties**

Thermal properties include heat resistance or combustibility. Thermoplastic has a larger coefficient of thermal expansion or combustibility and a smaller thermal conductivity or specific heat than other material such as metals.

- **Chemical properties**

Chemical resistance, environmental stress crack resistance , or resistance to environmental change are referred as chemical properties. When a plastic contacts chemicals, there is some kind of change. After having a plastic in contacted with chemicals under no stress for about a week, changes in appearance, weight and size of the plastic are examined.

- **Electric properties**

Electric properties are also referred to as electromagnetic properties. Electric properties include insulation, conductivity and electro-static charges. Due to their good insulation property, plastics are often used in electric fields. However, plastics do have a defect; they are easily electrified.

- **Physical properties**

Specific gravity, index of refraction and moisture absorption are called physical properties. The specific gravity of the plastic is small, and it varies depending on the character of high polymer , or thermal and mechanical treatment of the plastic.

Moulding of Thermoplastics,

Moulding Processes:-

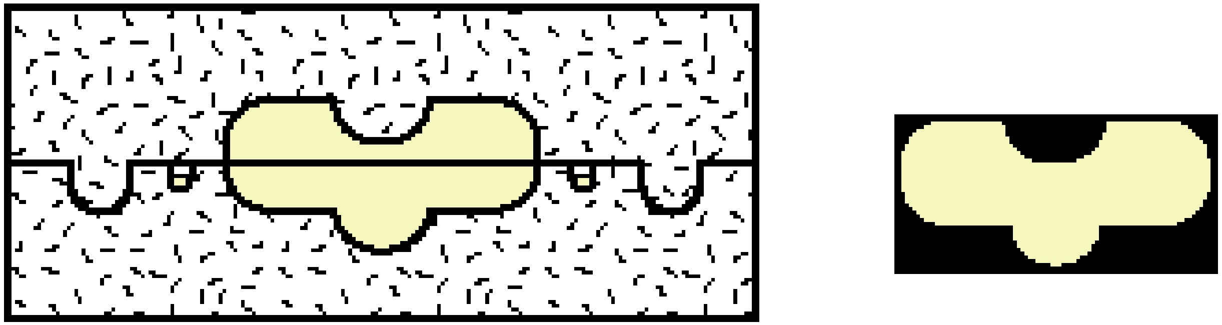
i. Compression Moulding
ii. Transfer Moulding
iii. Injection Moulding
iv. Jet Moulding
v. Extrusion

Compression molding

• Compression molding is a method of molding in which the molding material, generally preheated, is first placed in an open, heated mold cavity. The mold is closed with a top force or plug member, pressure is applied to force the material into contact with all mold areas, while heat and pressure are maintained until the molding material has cured.

Common plastics used in compression molding processes include

- Polyester
- Polyimide (PI)
- Polyamide-imide (PAI)
- Polyphenylene Sulfide (PPS)
- Polyetheretherketone (PEEK)
- Fiber reinforced plastics

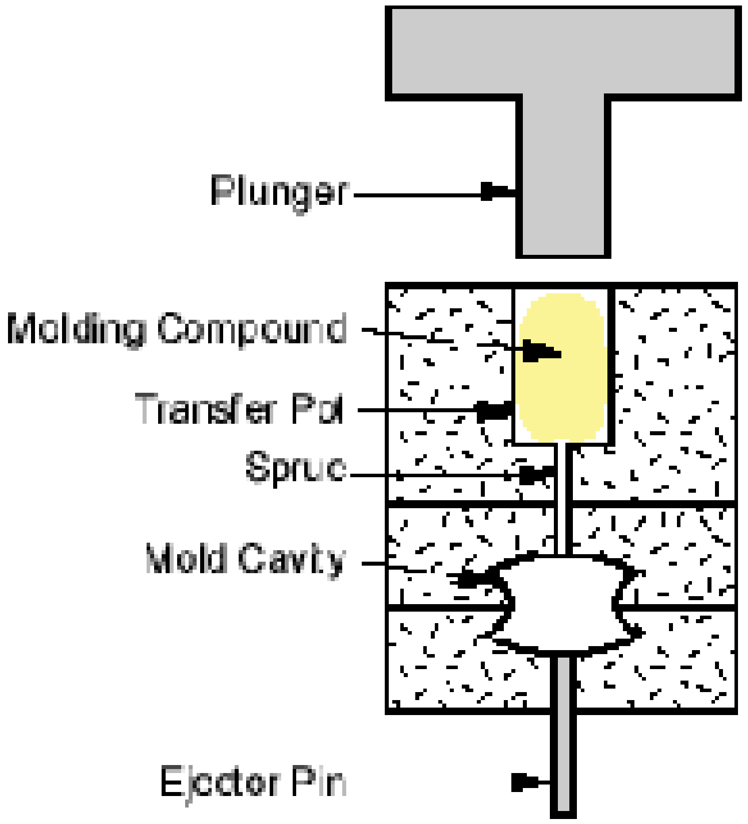


Transfer molding

• Transfer molding is similar to compression molding in that a carefully calculated, pre-measured amount of uncured molding compound is used for the molding process.

• The difference is, instead of loading the polymer into an open mold, the plastic material is pre-heated and loaded into a holding champers called the pot.

• The material is then forced/transferred into the pre-heated mold cavity by a hydraulic plunger through a channel called sprue. The mold remains closed until the material inside is cured.

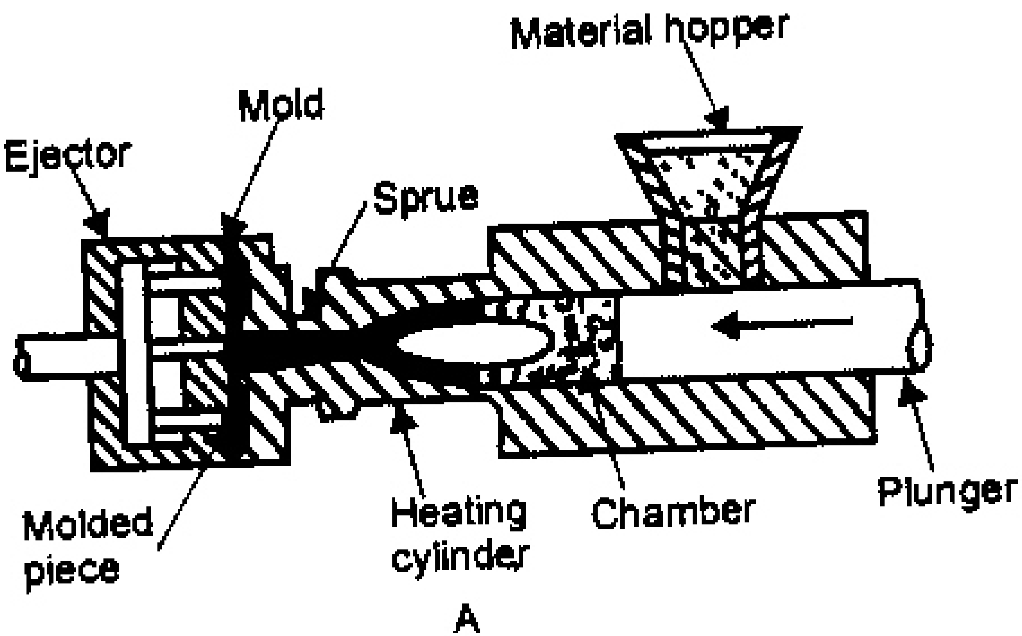


Injection molding

• Injection molding is a manufacturing process for producing parts from both thermoplastic and thermosetting plastic materials.

• Material is fed into a heated barrel, mixed, and forced into a mold cavity where it cools and hardens to the configuration of the mold cavity.

Conventional Single Stage Plunger Type:-



Jet Moulding

• A modified version of the Injection moulding is known as Jet Moulding Process.
• In this process the Plastic is preheated to about 93'C in the cylinder surrounding to nozzle.
• It is further heated as the plunger forces the resin through the nozzle.
• After the mould has been filled, the nozzle is cooled by running water to prevent polymerization of the remaining material.

Extrusion Moulding

• Extrusion is one of the most widely used manufacturing processes across many industries.
• Essentially, it is not much different from squeezing tooth paste out of the tube.
• Anything that is long with a consistent cross section is probably made by extrusion.
• Common examples are spaghetti, candy canes, chewing gums, drinking straws, plumbing pipes, door insulation seals, optical fibers, and steel or aluminum I-beams.

INJECTION MOULDING

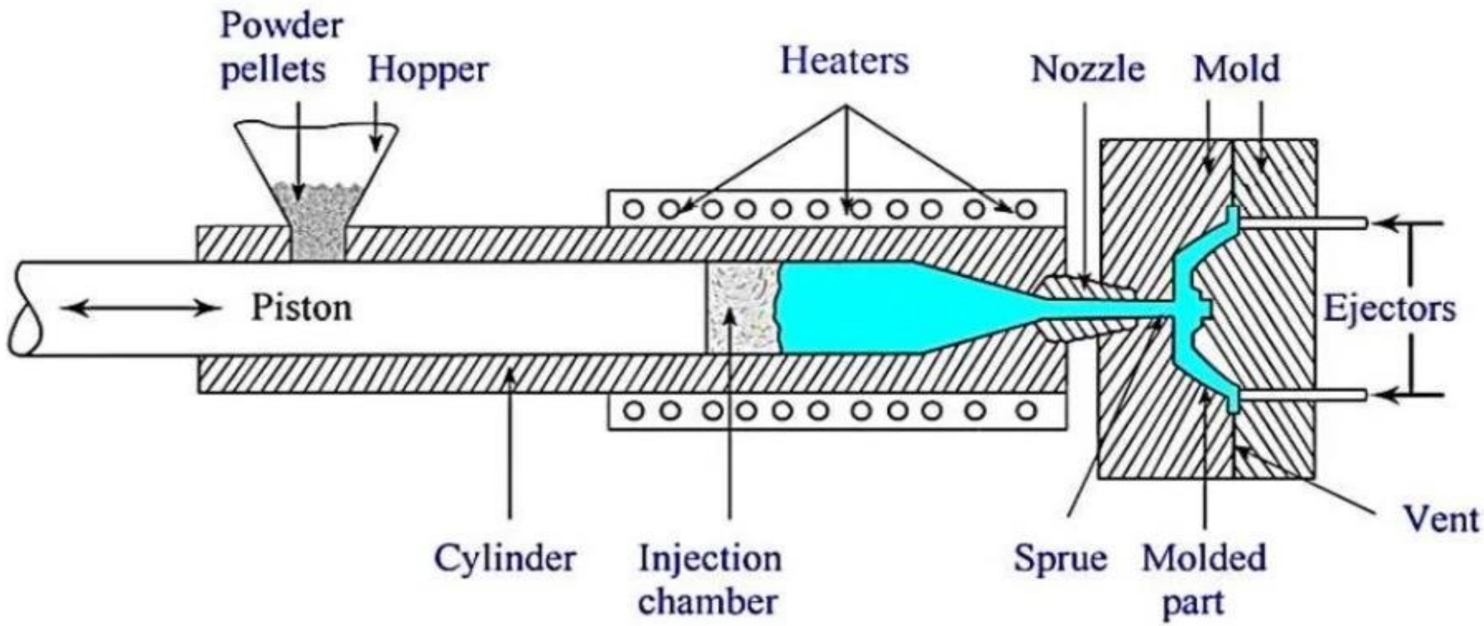


Figure 1 Injection molding setup

INJECTION MOULDING

- Palletized material is fed with use of hopper into a cylinder where material melts due to heating coils
- Molten metal is impelled through nozzle into the enclosed cavity
- Outstanding characteristic of this mounding process is cycle time is very less. i.e. rate of production is very high
- The complete injection molding process is divided into four stages: clamping, injection, cooling and ejection.

INJECTION MOULDING

- **Clamping:** The two halves of the mold must be tightly closed, before the molten plastic material is injected into the mold. One half of the mold is attached to the injection unit(nozzle) and other half is allowed to slide on the guideways

- **Injection:** During this process, the plastic material is melted by the application of heat and forwarded through the piston towards the nozzle and finally into the mold. The amount of material that is injected into the mold is referred to as the shot volume.

INJECTION MOULDING

Cooling:

- The injected molten plastic begins to cool as soonas it comes in contact with the mold surfaces.
- As the molded part cools, it will solidify into the desired shape of the product

Ejection:

- The molded part, which is attached to the rear half of the mold has to be ejected from the mold
- An ejector mechanism is used to push the part out of the mold
- Force must be applied to eject the plastic part because during cooling the molded part shrinks and adheres to the mold surface
- A mold release agent should be sprayed onto the moldsurfaces prior to injection of the material.

INJECTION MOULDING

Advantages

- Higher production rate
- Close tolerances on small intricate parts
- Minimum wastage of material
- Complex geometry can be easily produced

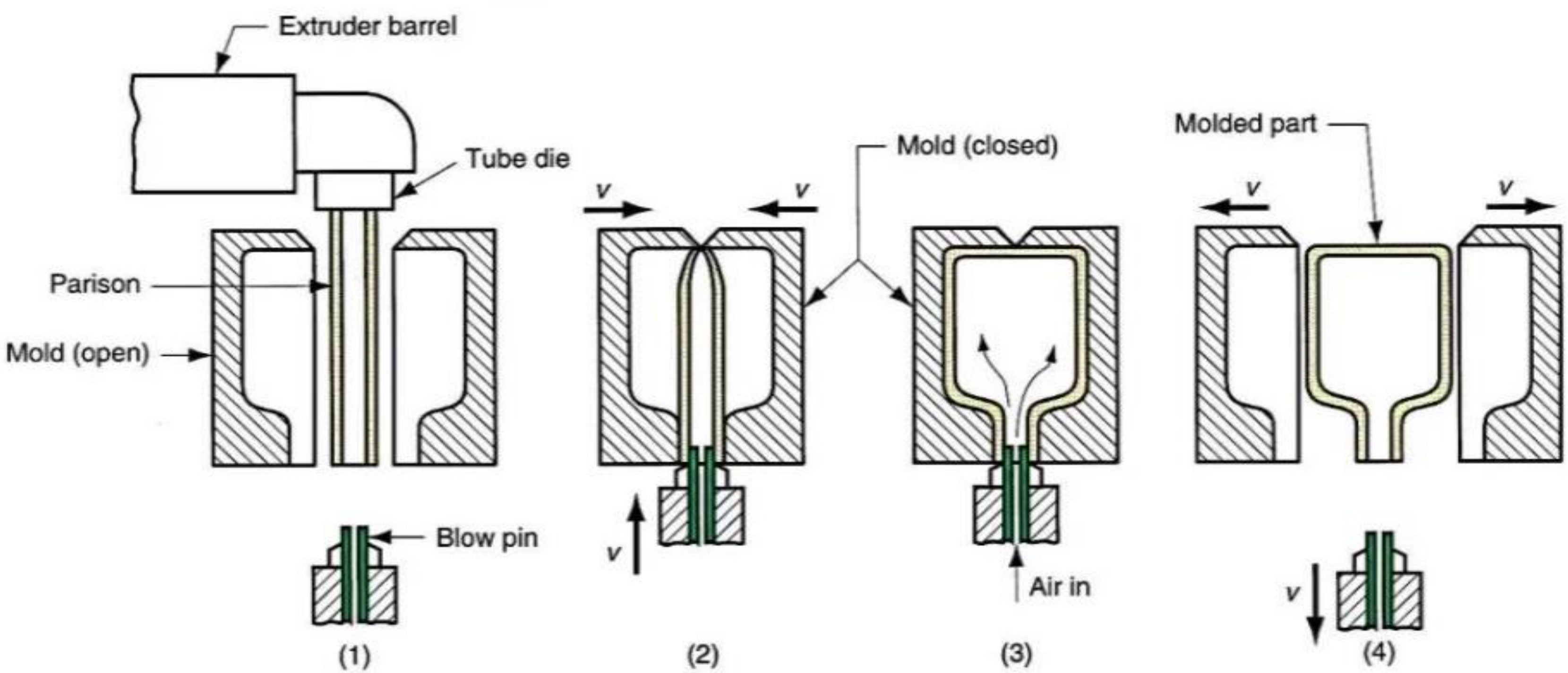
Disadvantages

- Tooling cost higher
- High setup cost
- Large undercuts can't be formed

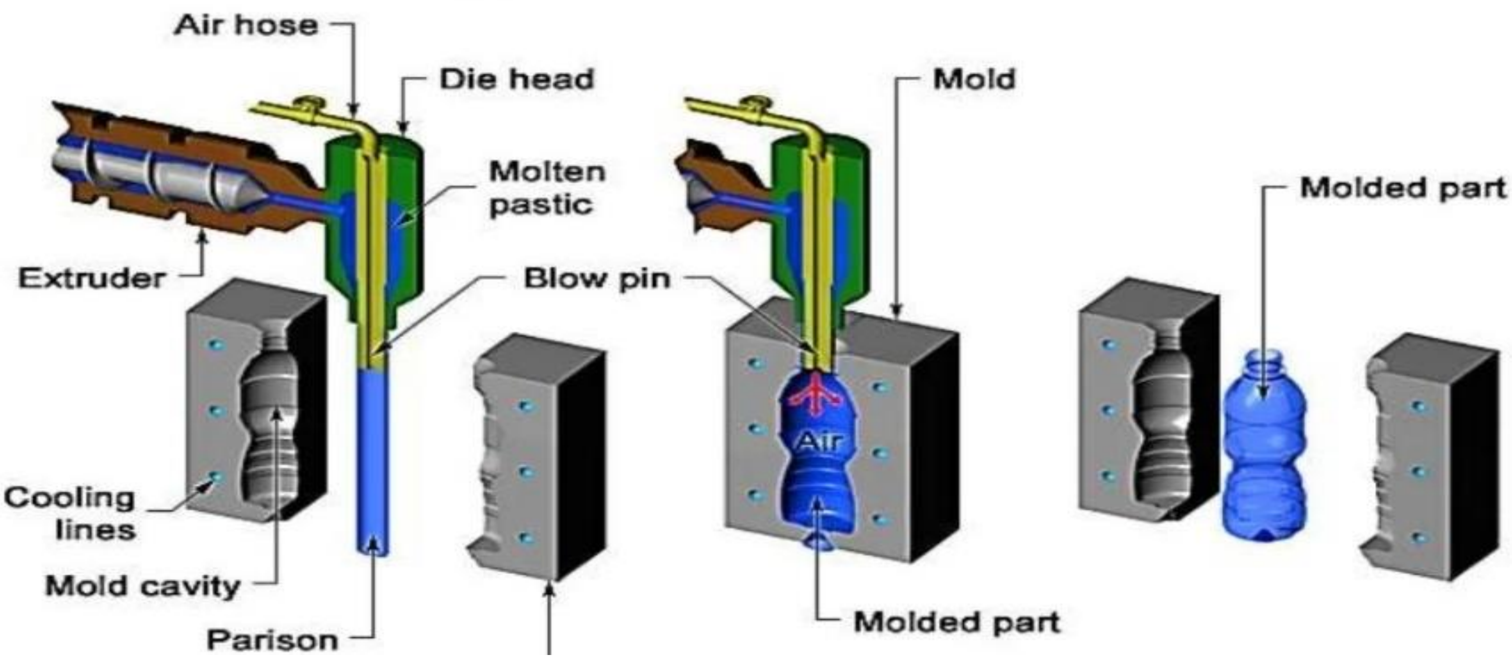
Applications

household appliances, electronics, and automotivedash boards, buckets etc...

BLOW MOULDING



BLOW MOULDING



BLOW MOULDING

- Using this manufacturing process blind parts are made like bottle or sphere etc
- Air is blown into a thin walled plastic cylinder called the parison. The parison is formed by melted plastic material being pushed through an extruder
- When the parison reaches a certain length, the two halves of the mould close around the parison sealing it at thebottom
- Compressed air is then used to inflate the parison to form the shape of the cavity inside the mould.

BLOW MOULDING

Advantages

- Low tooling cost
- Fast production rates
- Ability to mold complex part with uniform thickness
- Little scrap generated
- Large hollow shape can be produced

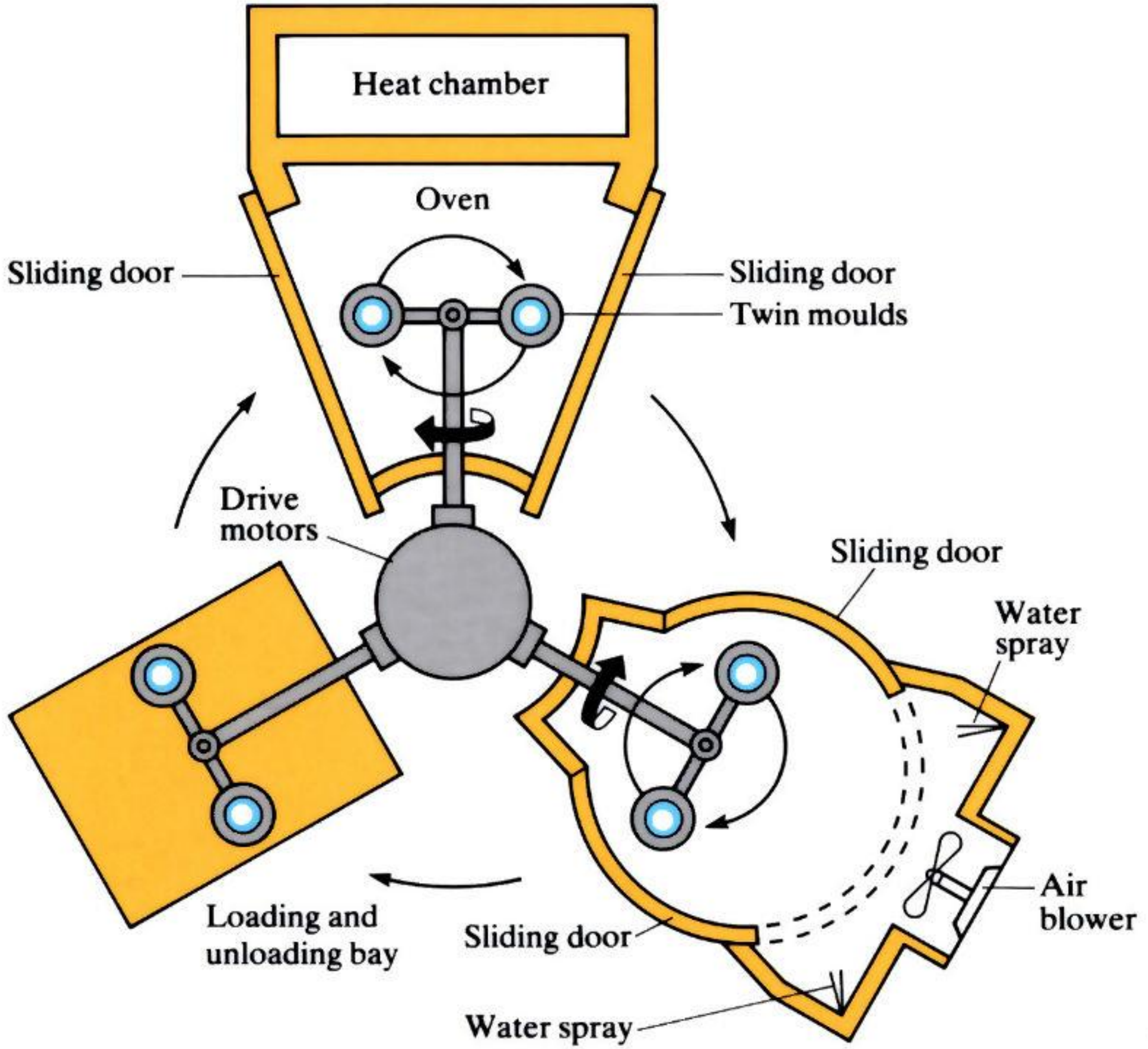
Disadvantages

- Limited to hollow parts
- Thick parts can't be manufactured

Applications

- Bottles in different shapeand size, jars, containers, mug ,toys, etc…

ROTATIONAL MOULDING



ROTATIONAL MOULDING

- Rotational moulding is a process of making hollow articles
- The part is formed inside a closed female mould
- In this process the mould rotates biaxially during heating and cooling cycle
- Rotational moulded pieces are stress free because the pieces are produced without any external pressure

ROTATIONAL MOULDING

Advantages

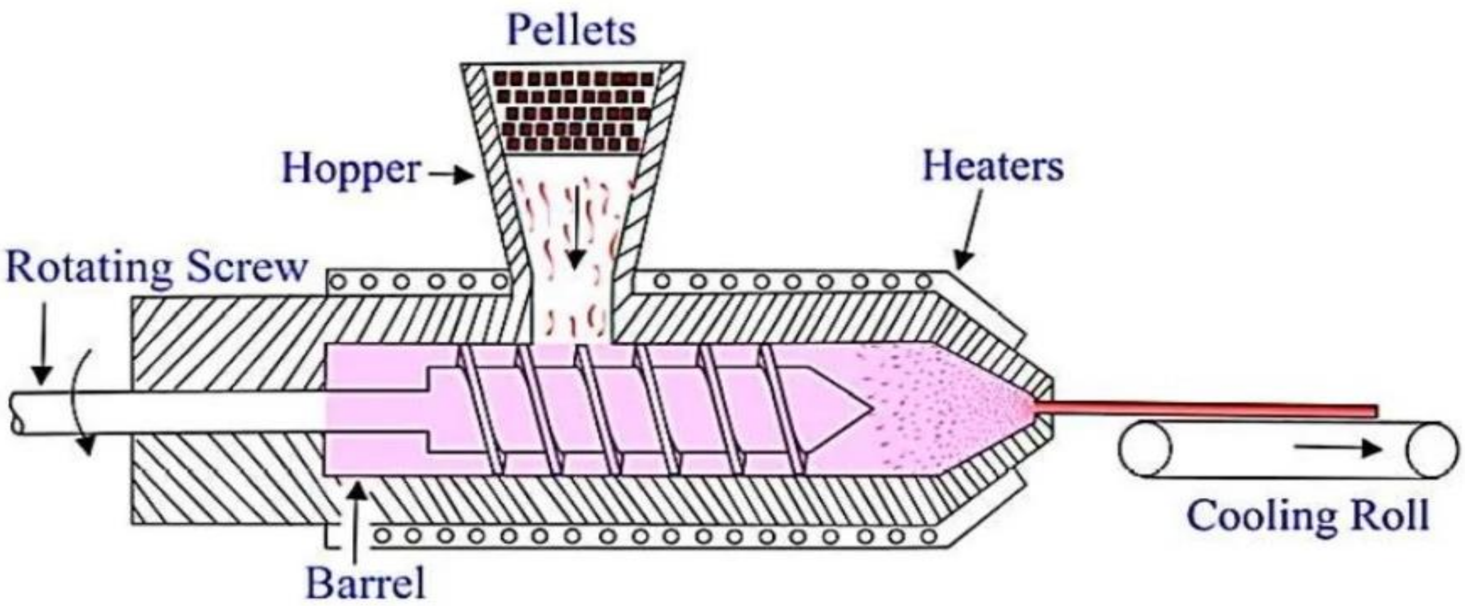
- The major advantage of rotational moulding as compared to other plastic moulding processes is that it can make very large parts
- It requires comparatively low cost input
- The products are stress free with strong out side corners. There are no sprue or gate marks
- Good control over wall thickness variation is also achievable as compared to blow moulding or thermoforming
- No scrap or very little scrap is produced
- Low tooling cost

ROTATIONAL MOULDING

Disadvantages

- The moulding cycles are longer compared to blow moulding and thermoforming
- In case of big parts loading and unloading isvery labour intensive
- The process is not suitable for parts with wall thickness less than 0.03”
- The conversion of plastic granules to powder form increases the equipment and process cost.

EXTRUSION MOULDING



- Similar to injection molding except long uniform sections are produced.
- The material which is fed through hopper, is conveyed forward by a feeding screw & forced through a die, converting to continuous polymer product.
- Heating is done in order to soften or melt the polymer. The temp is controlled by thermocouples.
- The product going out of the die is cooled by blown air or in water bath.

Advantages & Disadvantages of Extrusion Moulding

Advantages
- High production volumes
- Relatively low cost as compared with other molding process
- Design flexibility
- Short lead times
- Coating of wire can be done to achieves desired properties
- Continuous part can be produced

Disadvantages
- Limited complexity of parts
- Uniform cross section can only be produced

Applications of Extrusion Mouldling

- The extrusion process is used for manufacturing rods, plates and tubes, wire and cable coating, hose liners, hose mandrels, filaments, sheet, multilayer film, medical packaging and food packaging, etc.

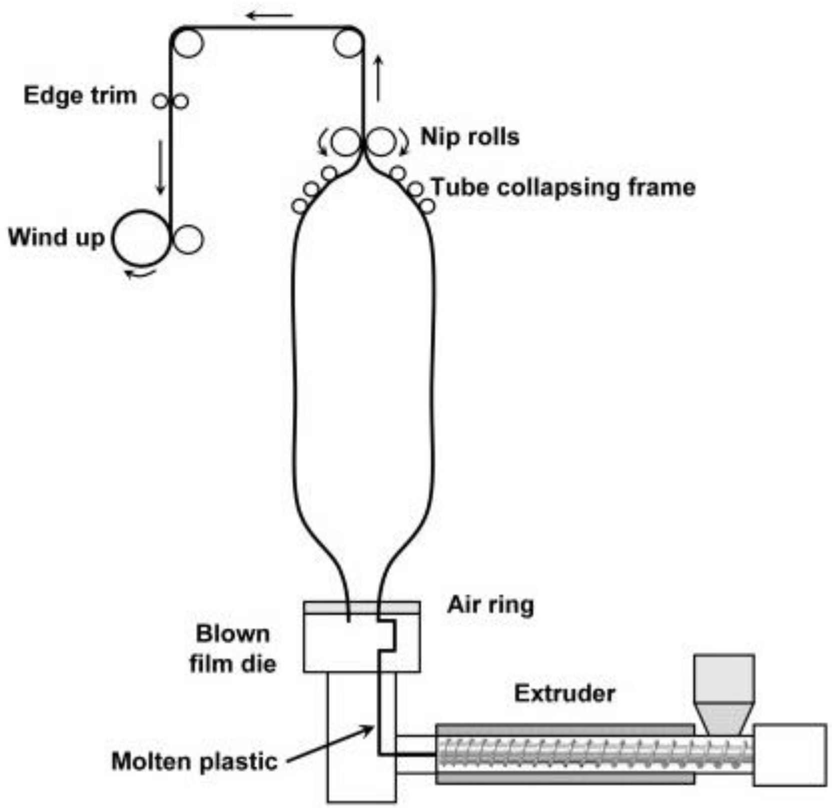
FILM BLOWING

- Film blowing or Blown film is **another extrusion processes used to fabricate film products**.
- In this case the extrusion die is shaped as a circle and air pressure is used to further expand the film. After it is expanded to the desired dimensions it is cooled to solidify the polymer.
- Plastic melt is extruded through an annular slit die, usually vertically, to form a thin walled tube. Air is introduced via a hole in the centre of the die to blow up the tube like a balloon. Mounted on top of the die, a high-speed air ring blows onto the hot film to cool it.

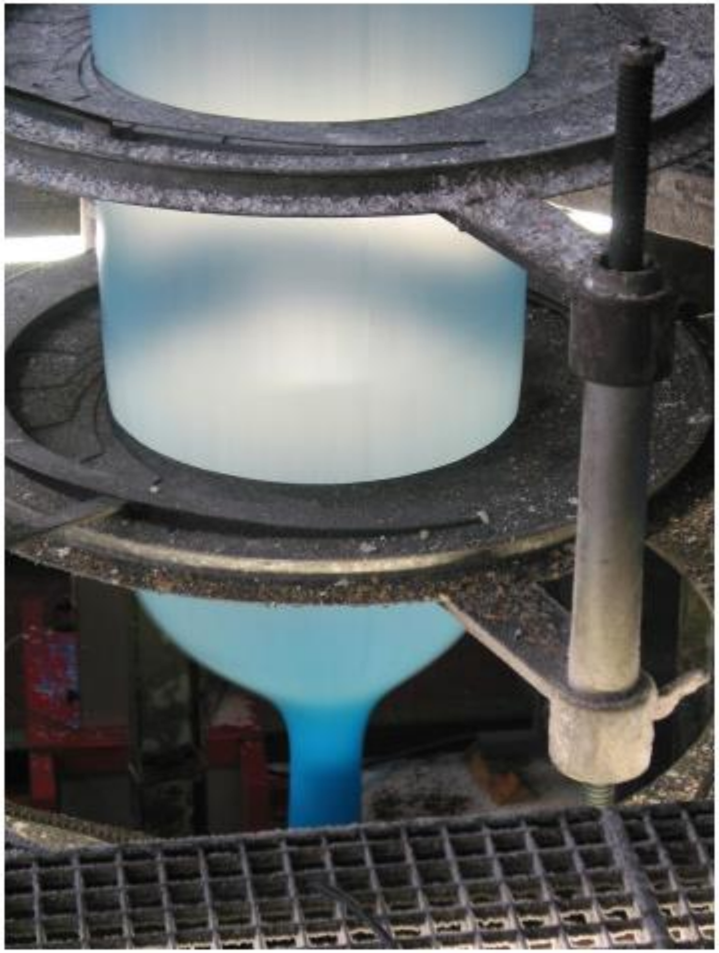
FILM BLOWING

- Blown Film Extrusion is an established process which is used to manufacture a wide range of commodity & specialized plastic films for the packaging industry.
- Also known as Film Blowing Process, this extrusion process generally comprises extrusion of molten thermoplastic tube and its constant inflation to several times of its initial diameter. This forms a thin, tubular product which may be used directly, or indirectly by slitting it to create a flat film.

FILM BLOWING



Schematic of blown film process



Photograph of film production by blowing process

Materials Used

- In the process of Blown Film Extrusion, the common resins that are used are Polyethylenes (LDPE, HDPE and LLDPE).
- Though, various other materials can also be used in this process, as a blend with resins or even as single layers in the multi-layer film structure. Some of these materials are PP, PP, and EVOH.
- In few instances when these materials are not able to gel together, then a multi-layer film might get de-laminate. Hence, to overcome this issue, various tiny layers of special adhesive resins are used purposefully in between. These tiny layers are called “tie layers”.

Advantages of Film blowing

In a single operation, flat as well as gusseted tubing are formed
Regulation of film thickness and width with the control of air volume in the bubble
Elimination of the end effects like edge bead trim along with non-uniform temperature which can cause from flat die film extrusion
Capability of biaxial orientation, which allows uniformity in all the mechanical properties
Very high productivity
Allows combination of different materials as well as properties

Applications Of Blown Film Extrusion

In this extrusion process, the blown film is used either in tube form (for plastic sacks and bags) or a sheet can be used by slitting the tube. Typical applications of the Blown Film Extrusion or Film Blowing includes following:

1. Industry Packaging
2. Consumer Packaging
3. Laminating film
4. Barrier film
5. Films for packaging medical products

THERMOFORMING

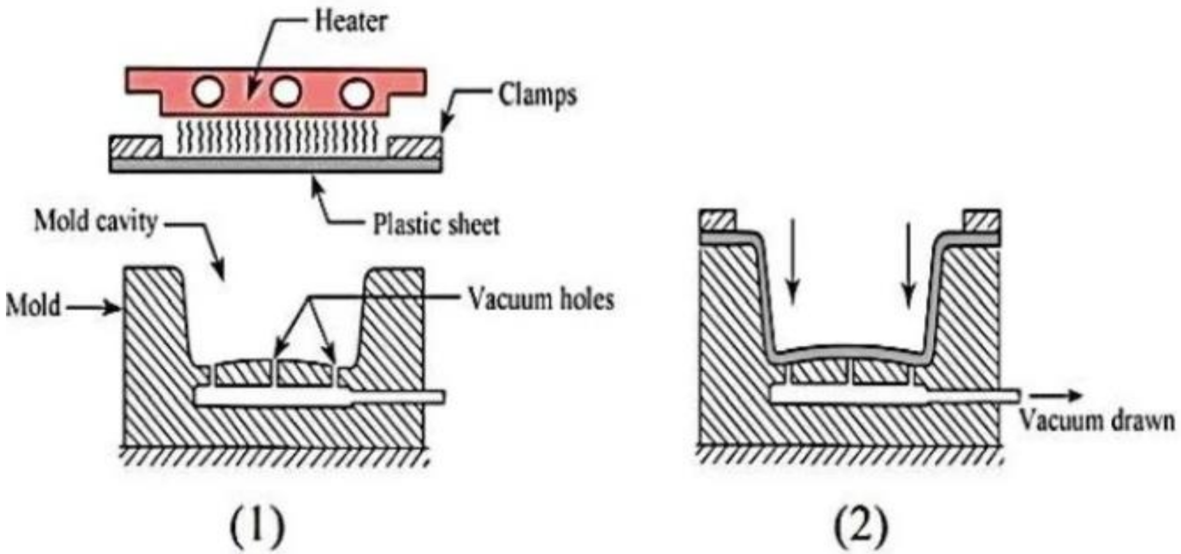
- Thermoforming is a plastic manufacturing process in which the thermoplastic sheets are formed with the application of heat and pressure in a mold.
- The thermoplastic sheet is held horizontally over a mold surface and clamped with a holding device. The sheet is heated up to predetermined temperature using a heating element called heater.
- The thermoplastic sheet softens with the application of heat and is pressed into or stretched over the mold surface by application of air pressure or by any other means.

THERMOFORMING

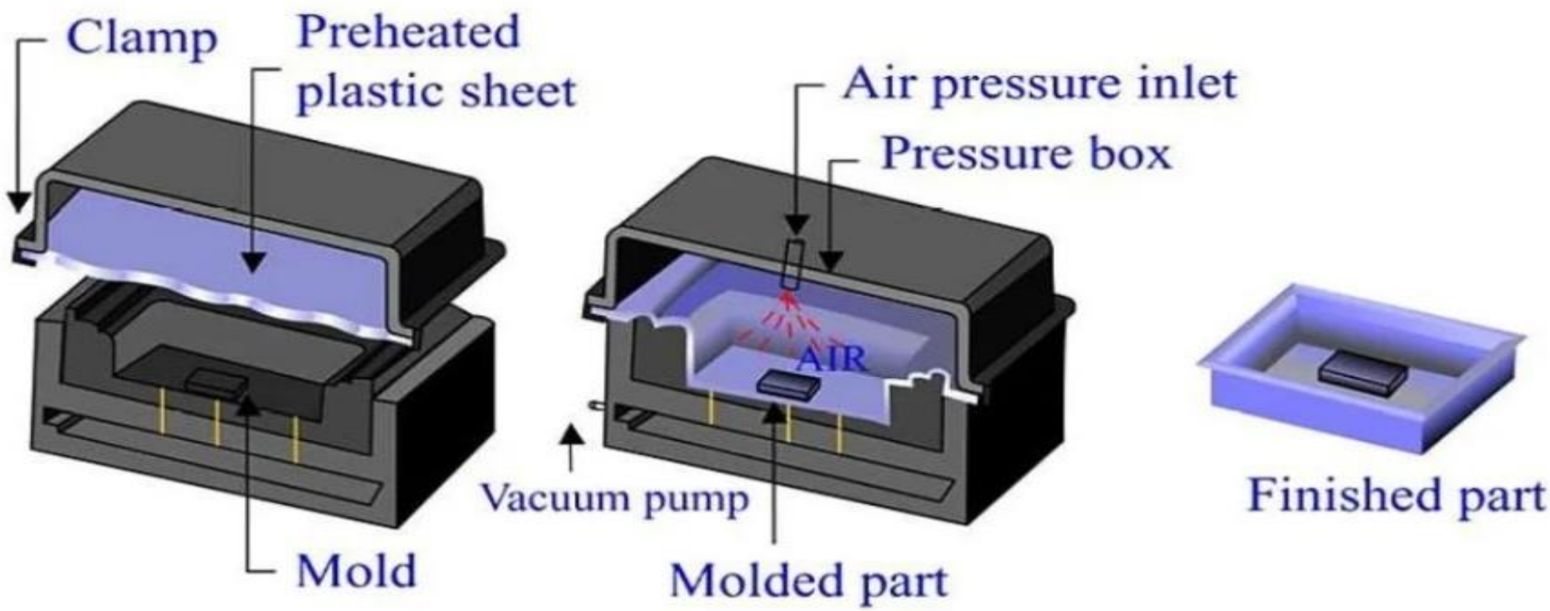
- The softened sheet conforms to the mold shape and it is held in place until it cools.
- The mold cavity is opened and the thermoformed part is released.
- The excess material is then trimmed out from the formed part. Excess material can be reground, mixed with unused plastic, and again reformed into thermoplastic sheets.
- There are mainly three different types of thermoforming process depending upon the pressure required i.e., vacuum thermoforming, pressure thermoforming and mechanical thermoforming.

TYPES OF THERMOFORMING

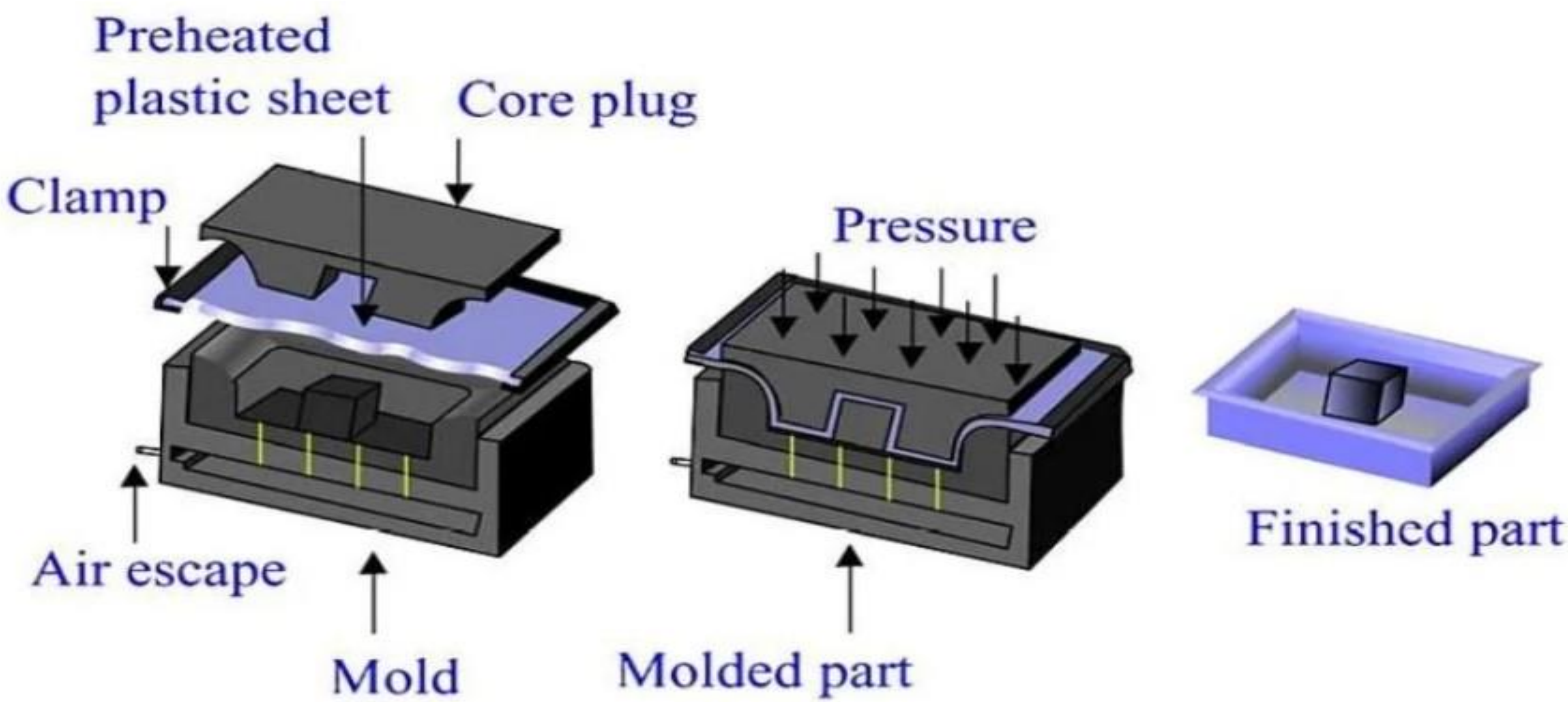
a. vacuum thermoforming



b. pressure thermoforming



c. mechanical thermoforming



Advantages & Disadvantages of Thermoforming

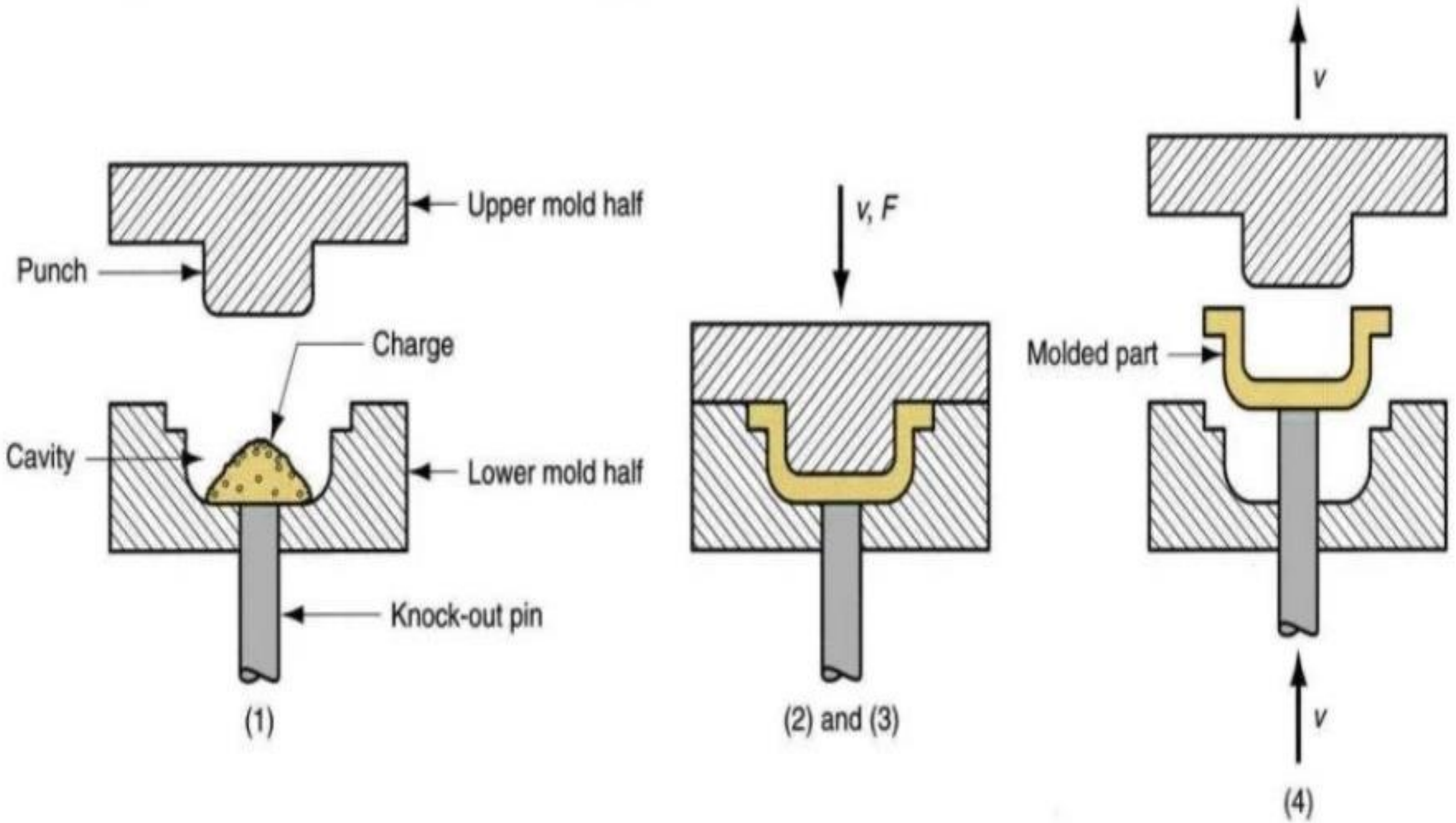
Advantages
- Extremely adaptive to design requirement
- Rapid prototype development
- Low initial setup costs
- Low production costs
- Less thermal stresses than injection molding and compression molding
- Good dimensional stability

Disadvantages
- Poor surface finish
- Parts may have non-uniform wall thickness.
- All parts need to be trimmed
- Ribs and bosses cannot be molded easily
- Very thick plastic sheets can't be formed

Applications of Thermoforming

- food packaging, automotive parts, trays, building products, aircraft windscreens, medical equipment, material handling equipment, electrical and electronic equipment, spas and shower enclosures etc.

Compression Moulding



Compression Moulding

•First, the charge is loaded into the lower half of mold which is preheated to maintain the temperature of charge during the process.

•The placed charge is compressed by bringing both halves of mold close together.

•The charge is heated by means of the hot mold to polymerize and cure it into a solidified desired shaped molded plastic component.

•Then, the halves are opened & molded plastic part is removed by pressing knockout pins towards inside.

Compression Moulding

Advantages

•Low initial setup costs and fast setup time
•Heavy plastic parts can be molded
•Complex intricate parts can be made
•Good surface finish of the molded parts
•Wastes relatively little material as compared with other methods
•The molding process is cheaper as compared to injection molding

Disadvantages

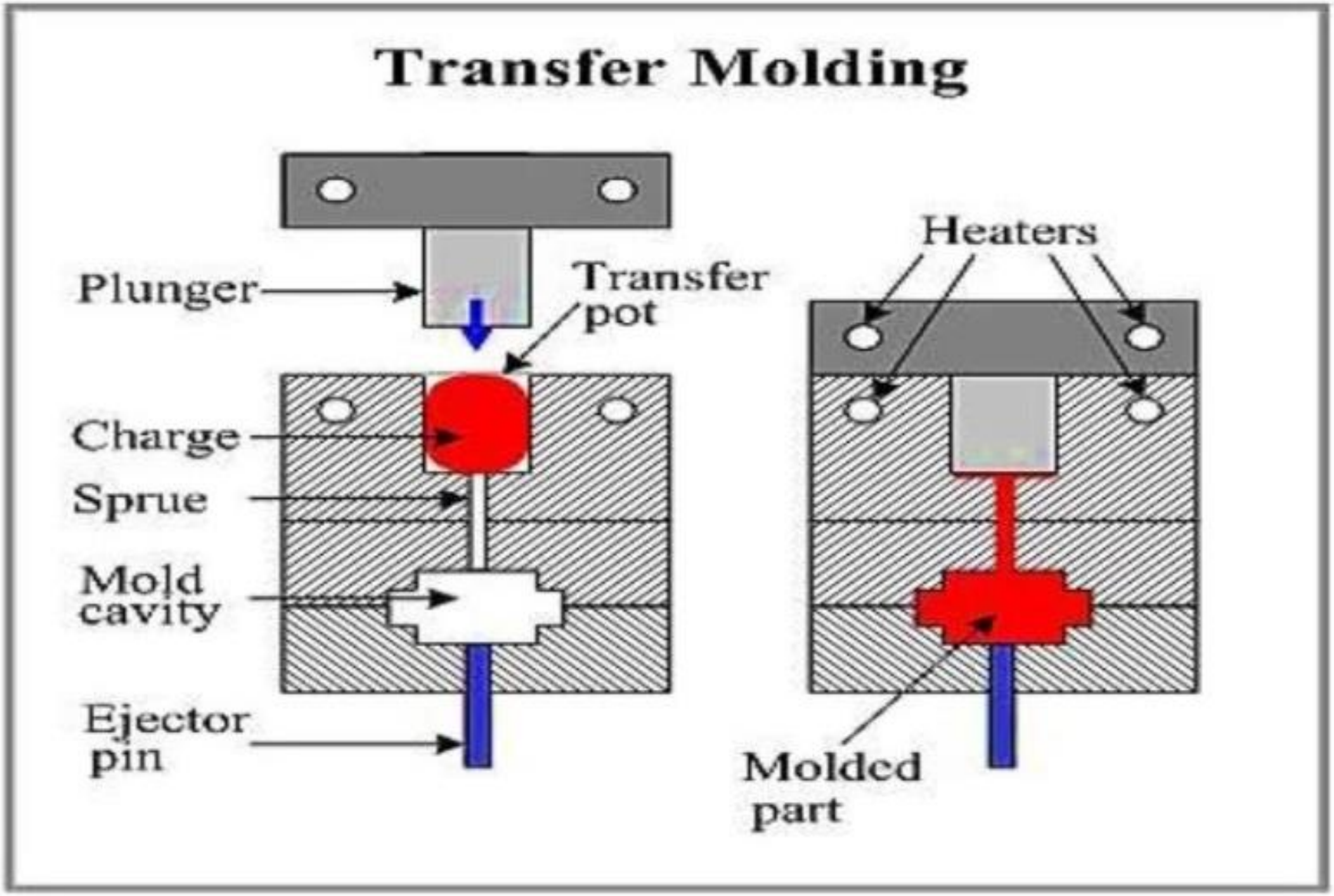
- Low production rate
- Limited largely to flat or moderately curved parts with no undercuts

Compression Moulding

Applications

- Electrical and electronic equipments, brush and mirror handles, trays, cookware knobs, aircraft main power terminal housing, pot handles, dinnerware plates, automotive parts.

Transfer Moulding



Transfer Moulding

•It is similar to compression molding. The difference is, instead of loading the polymer into an open mold, the plastic material is preheated and loaded into a holding chamber called pot.

•The material is then forced into a preheated mold cavity using a ram or hydraulic plunger through a channel called sprue.

•The mold remains closed until the material inside is cured.

•Then, the final molded part is removed by using ejector pin.

Transfer Moulding

Advantages

- Fast setup time and lower setup costs
- Low maintenance cost
- Plastic parts with metal inserts can be made
- Design flexibility
- Dimensionally stable
- Uniform thickness of parts
- Large production rate

Disadvantages

- Wastage of material
- Production rate lower than injection molding
- Air can be trapped in the mold

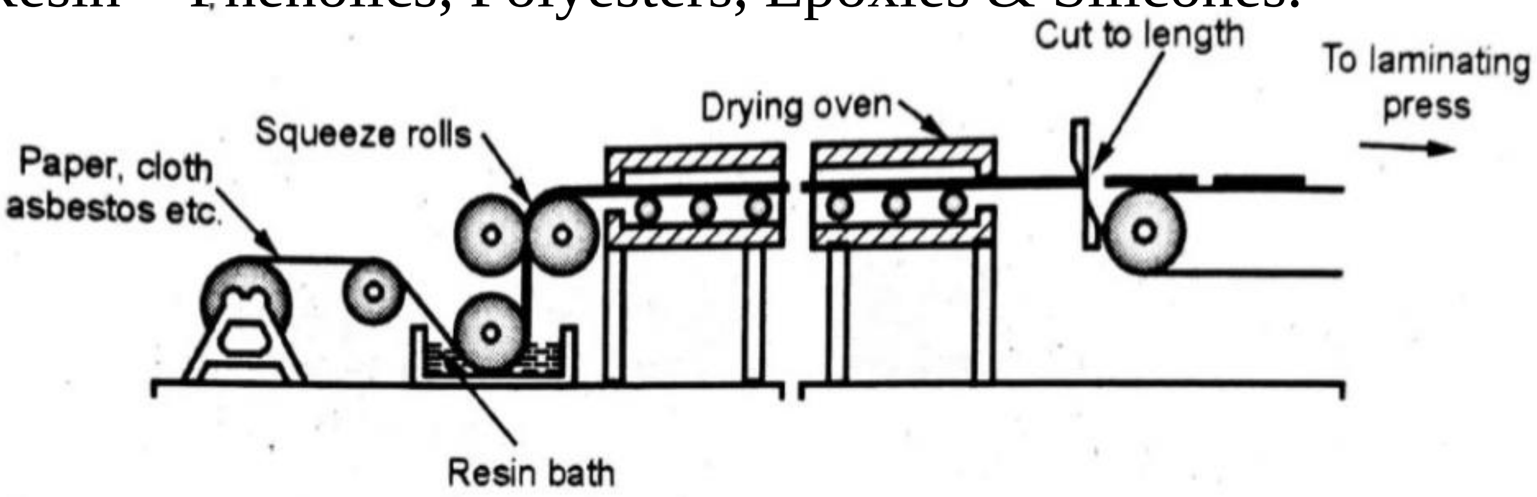
Transfer Moulding

Applications

- Integrated circuits, plugs, connectors, pins, coils, studs, radio, television cabinets and car body shells.

Bonding

- It is performed by the application of Heat & Pressure
- Laminated plastics consists of sheets of paper, fabric, wood or other similar materials that are coated with resin.
- The layers are properly cut as per the requirement
- Layers of sheet like metal foil, paper bonded together in a stack.
- Sheet Thickness— 0.05 — 0.12mm
- Pressure = 8 -24Mpa
- Resin = Phenolics, Polyesters, Epoxies & Silicones.



Vibration Welding

Vibration Welding

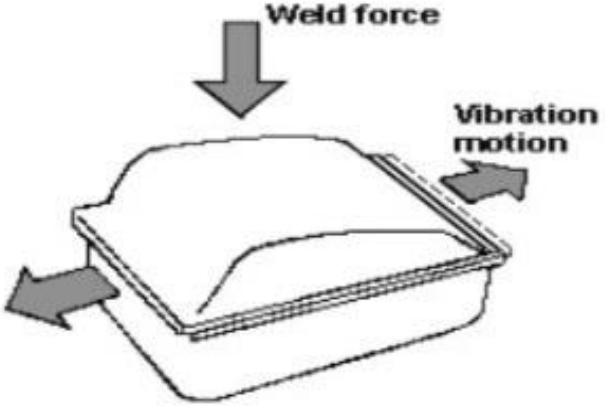
• To produce pressure tight joints in circular, rectangular or irregular shaped components made from thermoplastics

•Weld joint in single plane

•Hollow container can be welded

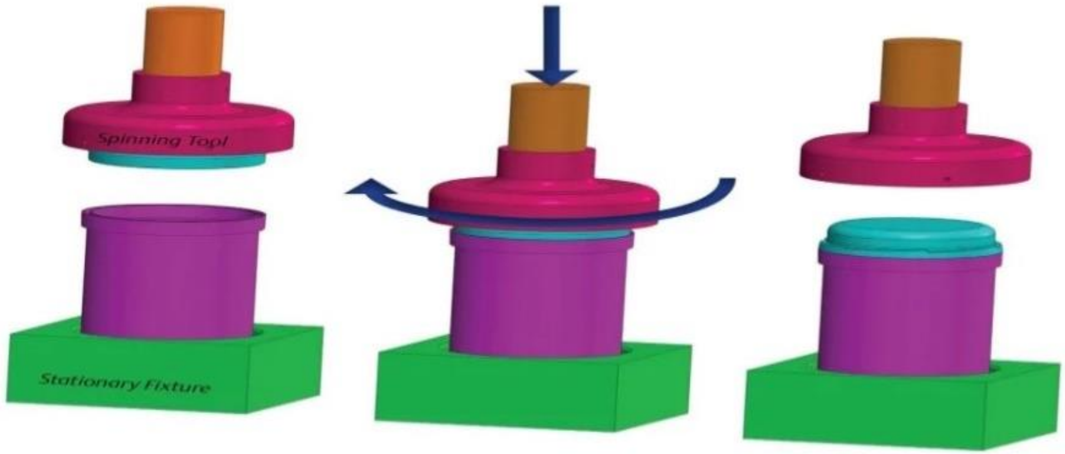
•The friction is developed by pressing two plastic components & vibrating them at 120 cycles/sec in the plane of joint.

•The pressure should be maintained until soften plastic cools



The principle of vibration welding

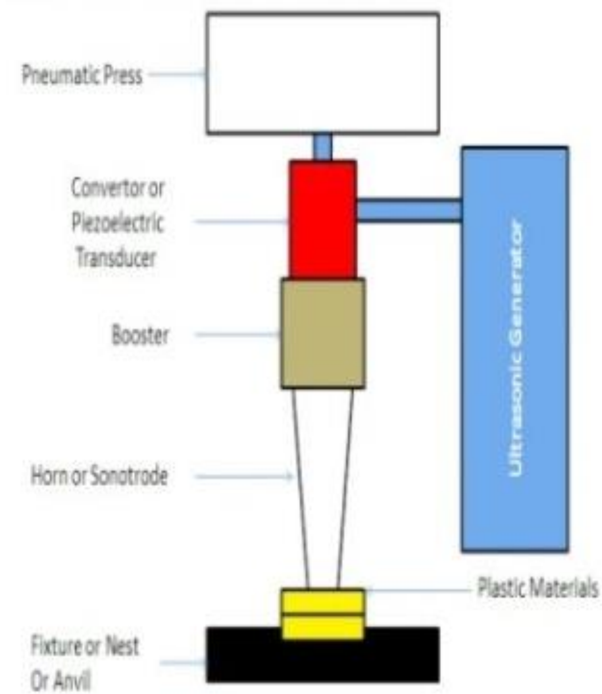
Spin Welding



- One component is fixed
- Another component is attached to the spindle
- The spindle is rotated at predetermined speed and then forced against the stationary component
- Heat generated at the junction due to friction
- Only symmetrical components can be joined

Ultrasonic Welding

•The two plastic pieces to be joined is assembled in the nest (anvil or fixture)
•The horn is made to contact at upper part of the piece.
•A pressure is applied on the two pieces against the fixture. The pressure is applied through the pneumatic or electric driven press.
•Due to local plastic deformation & heat generate due to friction between contact surfaces, Joint formation will takes place.
•A clamping force is applied on the two pieces for a predetermined amount of time to fuse them together to form a strong weld on cooling and solidification.
•After solidification, the clamping force is removed and horn retracted. The welded plastic part is taken out of the fixture as one piece.



HORN OR SONOTRODE

20 kHz to 40 kHz

It vibrates at high frequency and transmits the mechanical vibration to the two pieces to be welded. It takes the shape of the part. The horn is made of **titanium or aluminum.**

Ultrasonic Welding

Advantages

•It is fast welding process.
•It can be easily automated.
•It produces clean and precise joint.
•It produces low thermal impact on the materials.

Disadvantages

• It cannot be used to produce large joints (greater than 250 x 300 mm).
• It requires especially designed joints, so it can make tip contact during welding process.
• High tooling cost for the fixtures.
•Ultrasonic welding process is restricted to the lap joints.

Ultrasonic Welding

Applications

- Computer and Electrical Industries: Here it is used to join wired connections and to create connections in small delicate circuits.
- It is used for packaging dangerous materials like explosives, fireworks and chemical.
- Items such as anesthesia filters, blood filters, dialysis tubes

Induction/Electromagnetic Bonding

- Suitable for thermoplatic

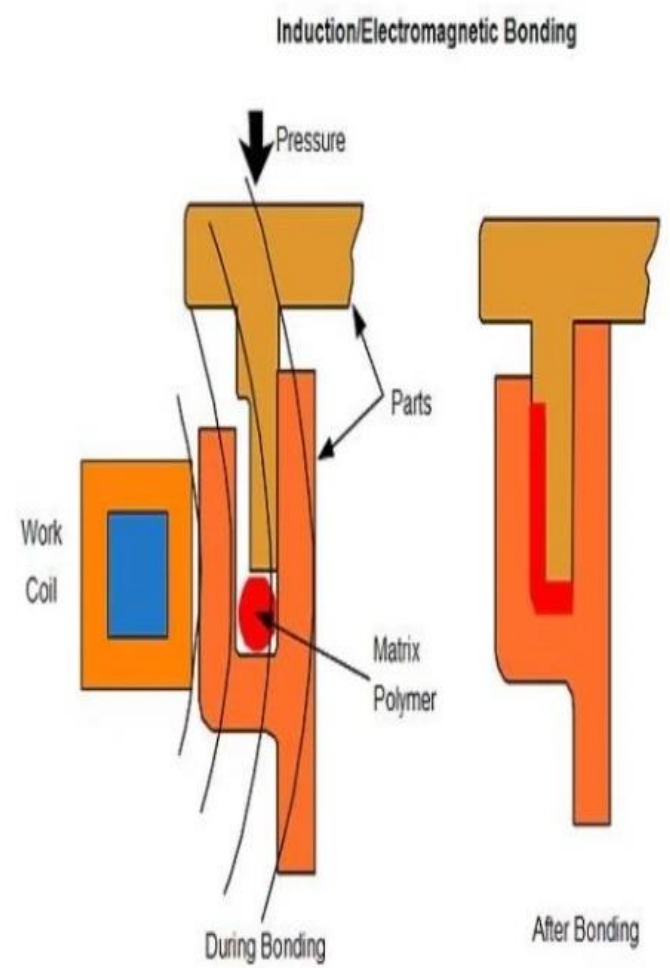
•Two components are pressed together

•High frequency magnetic field is supplied to the joint by the working coil.

•This magnetic field heating the matrix polymer, then melting the plastic & compression produces good fusion weld.

•High cost technique

•Metal powders may be added to the original plastic moulding, but it requires high frequency.



Solvent Bonding

•Only thermoplastics can be joined by softening them by solvent & then clamping or pressing together.

•The plastic molecules intermingle & the components bond together as the solvent evaporates.

•Time of fusion is direct function of solvents evaporation rate.

•The pressure applied on the component is critical because high pressure may deflect the components.